**Fishery Data Series No. 12-51**

# Production and Escapement of Chilkat River Coho Salmon, 2008–2009

**by**

**Brian W. Elliott**

**September 2012**

**Alaska Department of Fish and Game** **Divisions of Sport Fish and Commercial Fisheries**

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**Weights and measures (metric)**

| | |
|---|---|
| centimeter | cm |
| deciliter | dL |
| gram | g |
| hectare | ha |
| kilogram | kg |
| kilometer | km |
| liter | L |
| meter | m |
| milliliter | mL |
| millimeter | mm |

**Weights and measures (English)**

| | |
|---|---|
| cubic feet per second | $ft^3/s$ |
| foot | ft |
| gallon | gal |
| inch | in |
| mile | mi |
| nautical mile | nmi |
| ounce | oz |
| pound | lb |
| quart | qt |
| yard | yd |

**Time and temperature**

| | |
|---|---|
| day | d |
| degrees Celsius | °C |
| degrees Fahrenheit | °F |
| degrees kelvin | K |
| hour | h |
| minute | min |
| second | s |

**Physics and chemistry**

| | |
|---|---|
| all atomic symbols | |
| alternating current | AC |
| ampere | A |
| calorie | cal |
| direct current | DC |
| hertz | Hz |
| horsepower | hp |
| hydrogen ion activity (negative log of) | pH |
| parts per million | ppm |
| parts per thousand | ppt, ‰ |
| volts | V |
| watts | W |

**General**

| | |
|---|---|
| Alaska Administrative Code | AAC |
| all commonly accepted abbreviations | e.g., Mr., Mrs., AM, PM, etc. |
| all commonly accepted professional titles | e.g., Dr., Ph.D., R.N., etc. |
| at | @ |
| compass directions: | |
| east | E |
| north | N |
| south | S |
| west | W |
| copyright | © |
| corporate suffixes: | |
| Company | Co. |
| Corporation | Corp. |
| Incorporated | Inc. |
| Limited | Ltd. |
| District of Columbia | D.C. |
| et alii (and others) | et al. |
| et cetera (and so forth) | etc. |
| exempli gratia (for example) | e.g. |
| Federal Information Code | FIC |
| id est (that is) | i.e. |
| latitude or longitude | lat. or long. |
| monetary symbols (U.S.) | $, ¢ |
| months (tables and figures): first three letters | Jan,...,Dec |
| registered trademark | ® |
| trademark | ™ |
| United States (adjective) | U.S. |
| United States of America (noun) | USA |
| U.S.C. | United States Code |
| U.S. state | use two-letter abbreviations (e.g., AK, WA) |

**Mathematics, statistics**

| | |
|---|---|
| *all standard mathematical signs, symbols and abbreviations* | |
| alternate hypothesis | $H_A$ |
| base of natural logarithm | *e* |
| catch per unit effort | CPUE |
| coefficient of variation | CV |
| common test statistics | (F, t, $\chi^2$, etc.) |
| confidence interval | CI |
| correlation coefficient (multiple) | R |
| correlation coefficient (simple) | r |
| covariance | cov |
| degree (angular ) | ° |
| degrees of freedom | df |
| expected value | *E* |
| greater than | > |
| greater than or equal to | ≥ |
| harvest per unit effort | HPUE |
| less than | < |
| less than or equal to | ≤ |
| logarithm (natural) | ln |
| logarithm (base 10) | log |
| logarithm (specify base) | $log_2$, etc. |
| minute (angular) | ' |
| not significant | NS |
| null hypothesis | $H_O$ |
| percent | % |
| probability | P |
| probability of a type I error (rejection of the null hypothesis when true) | α |
| probability of a type II error (acceptance of the null hypothesis when false) | β |
| second (angular) | " |
| standard deviation | SD |
| standard error | SE |
| variance | |
| population | Var |
| sample | var |

# *FISHERY DATA SERIES NO. 12-51*

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# ABSTRACT

The purpose of this study was to conduct a full stock assessment of Chilkat River coho salmon *Oncorhynchus kisutch*. Coho salmon smolt were captured in the Chilkat River during spring 2008, marked with an adipose fin clip and a coded wire tag (CWT), and sampled for age, weight, and length. In 2009, adult coho salmon were sampled for CWTs in sport and commercial fishery harvests throughout Southeast Alaska and in the Chilkat River to estimate the marked fraction. The 2009 escapement to the Chilkat River was estimated by expanding peak survey counts.

An estimated 716,689 (SE = 88,013) coho salmon smolt emigrated from the Chilkat River in 2008. Most (86.6%, SE = 1.7%) of the smolt emigrating were age-1. In 2009, the total (non-jack) return of Chilkat River coho salmon was estimated at 80,893 (SE = 9,584), of which 30,558 (SE = 2,585) were harvested in marine fisheries, 2,424 (SE = 421) were harvested inriver, and 48,867 (SE = 9,402) escaped into the Chilkat River. Most (46.0%) of the harvest occurred in the District 115 drift gillnet fishery (15,179, SE = 1,437). The majority of the escapement was age-1.1 (2006 brood year, 83.4%, SE = 1.3%), and male (60.7%, SE = 1.1%). The marine survival (smolt-to-adult) and exploitation rates were estimated at 11.3% (SE = 1.9%) and 37.8% (SE = 4.7%), respectively.



Key words: abundance, escapement, coded wire tag, harvest, contribution, subsistence fishery, recreational fishery, troll fishery, drift gillnet fishery, seine fishery, age composition, size composition, sex composition, length-at-age, marine survival, exploitation rate, coho salmon, Oncorhynchus kisutch, Chilkat River, Haines, Southeast Alaska


# INTRODUCTION

The purpose of this study was to conduct a full stock assessment of Chilkat River coho salmon *Oncorhynchus kisutch*. The long-term goal of this study is to gather information needed to manage harvests in accordance with sustained yield principles.

The Chilkat River produces annual adult returns of 100,000 to 300,000 coho salmon, making it one of the largest in Southeast Alaska. Research conducted during the 1980s on coho salmon stocks in Lynn Canal (including the Chilkat River) concluded that these stocks have, at times, been subjected to very high (over 85%) exploitation rates (Elliott and Kuntz 1988; Shaul et al. 1991).

The Chilkat River is a large glacial system that originates in British Columbia, Canada, flows through rugged dissected mountainous terrain, and terminates in Chilkat Inlet near Haines, Alaska (Figure 1). The mainstem and major tributaries comprise approximately 350 km of river channel in a watershed covering about 2,600 km² (Bugliosi 1988).

The economic impact of sport fishing in Southeast Alaska is considerable and constitutes a significant component of the overall economy for both Southeast Alaska and the Haines/Skagway management area, as indicated by recent studies. Overall in 2007, anglers spent $274 million in Southeast Alaska, including $175 million by non-resident anglers. Nonresident anglers fishing in Southeast Alaska spent an average of $403.94 per day on sport fishing activities (all types combined) in 2007, while residents spent an average of $102.54 per day of fishing (Southwick Associates Inc. et al. 2008). The freshwater coho salmon fishery in Haines provides a small but important component of the local economy and sport fishery in Southeast Alaska. In 1988, anglers fishing in Haines and Skagway for coho salmon spent an estimated $181,000 (Jones & Stokes 1991). This fishery operates late in the year when other fisheries have finished and is popular with local and non-local anglers. In 2007, 79.5% of anglers who fished in freshwater areas of Haines were nonresidents (Jennings et al. 2010a), and while they may spend less than the average for Southeast Alaska, their economic impact in Haines is significant.

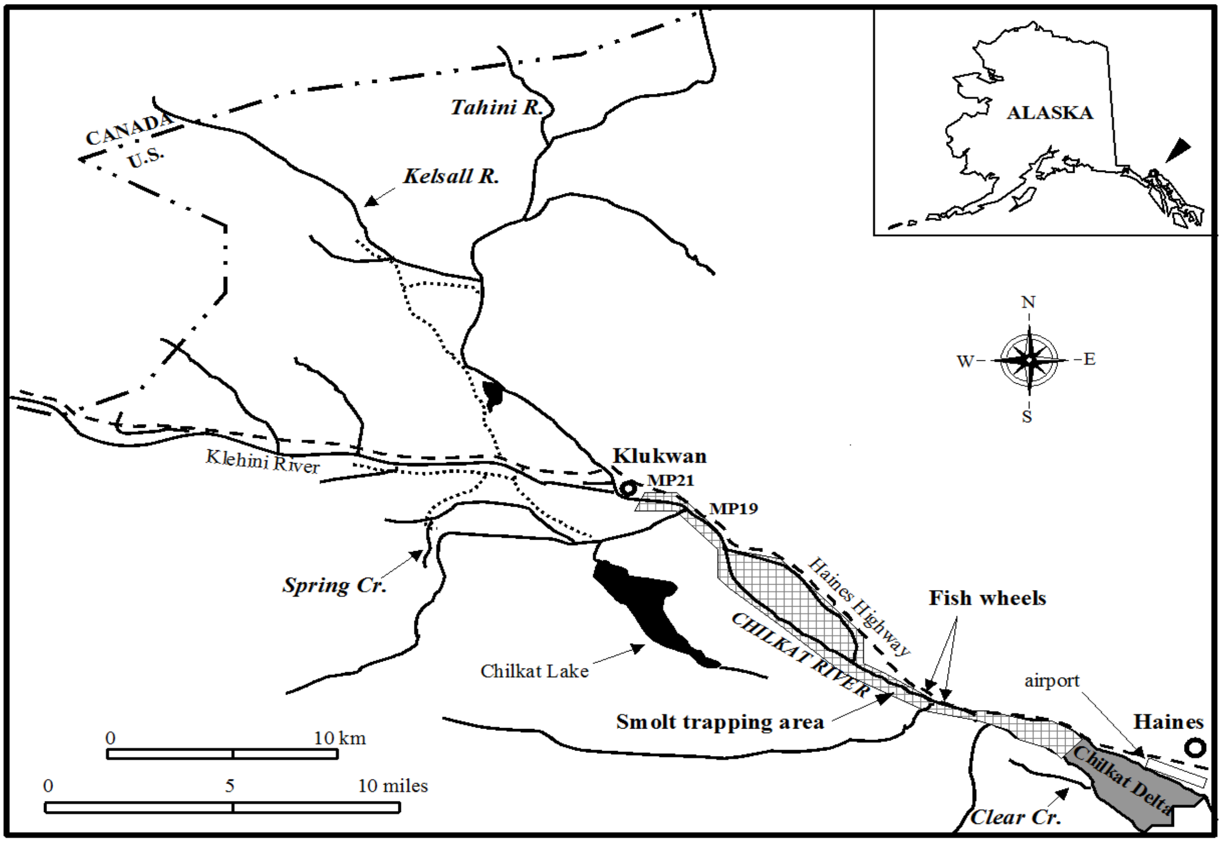


Figure 1.–The Chilkat River drainage, showing location of sampling sites.

The Chilkat River produces most of the coho salmon harvested in the Haines management area and supports one of the largest freshwater coho fisheries in Southeast Alaska; annual harvests have averaged 2,020 coho salmon from 2000 to 2008 (Howe et al. 2001; Jennings et al. 2004, 2006a-b, 2007, 2009 a-b;  2010a-b; Walker et al. 2003). This stock also contributes a significant number (more than 60,000 per year) of fish to the commercial troll, gillnet, and seine fisheries in northern Southeast Alaska (Elliott and Kuntz 1988; Shaul et al. 1991; Ericksen 2001–2003; Ericksen and Chapell 2005; Elliott 2009, 2010; 2012).

The current management program for Chilkat River coho salmon relies on escapement monitoring on 4 index streams: Clear Creek, Spring Creek, Tahini River, and Kelsall River (Figure 1). Alaska Department of Fish and Game (ADF&G) personnel survey the index streams by foot or boat on a weekly basis in October during peak spawning, and count all observed coho salmon. The peak number counted for each stream was used as the index count for that year. Peak survey count estimation has been performed consistently since 1987.

The escapement of coho salmon to the Chilkat River drainage has also been estimated by mark-recapture experiments in 5 years (1990, 1998, 2002, 2003, and 2005), and ranged from 38,589 (SE = 4,625) in 2005 to 205,429 (SE = 31,165) in 2002. (Table 1, Ericksen 2006).

This was the tenth consecutive year in this study designed to monitor the cycle of smolt production and subsequent adult return of Chilkat River coho salmon. Between 1999 and 2008, 750,000–3,000,000 smolt emigrated from the Chilkat River and contributed 12,000-131,000 adults to commercial, sport, and subsistence fisheries (Ericksen 2001; 2003, 2006; Ericksen and Chapell 2005; Elliott 2009, 2010; 2012).

# OBJECTIVES

Research objectives for this study were:

1. estimate the number of coho salmon smolt leaving the Chilkat River in 2008;
2. estimate the age composition of coho salmon smolt leaving the Chilkat River in 2008;
3. estimate the escapement of coho salmon to the Chilkat River in 2009;
4. estimate the age, sex, and length composition of adult (ocean age-1) coho salmon entering the Chilkat River in 2009; and
5. estimate the marine harvest of Chilkat River coho salmon in 2009.

# METHODS

During spring 2008, coho salmon smolt were captured in main channels of the Chilkat River and marked with an adipose fin clip and a coded wire tag (CWT). In 2009, adult coho salmon were sampled for CWTs in sport and commercial fisheries harvests throughout Southeast Alaska and in the Chilkat River to estimate the adipose-finclipped mark fraction ($\theta_{smolt}$ , or $\theta_s$) used to estimate abundance of the 2008 coho smolt emigration. The fraction of adipose-finclipped adult coho salmon sampled in the Chilkat River containing valid CWTs ($\theta_{marine,}$ or $\theta_m$) was used to estimate marine harvest of adult coho salmon in sampled fisheries in 2009.

## SMOLT CAPTURE, SAMPLING, AND MARKING

During spring 2008, smolt were captured in the main channels of the Chilkat River from the Haines airport (Haines Highway milepost [MP] 4) upstream to approximately MP 21 (Figure 1). Two 2-person crews fished approximately 100 G-40 minnow traps per day between April 10 and May 27. Traps were baited with disinfected salmon roe and checked at least once per day. Crew members immediately released coho salmon obviously less than 75 mm FL and non-target species at the capture site. Remaining fish were transported to holding pens for processing at the tagging site, located on the bank of the Chilkat River adjacent to MP 19. Water depth (cm) and temperature (°C) were recorded each morning near the tagging site. The weekly peak catch, as measured by coho smolt per minnow trap (CPUE), was determined.

Preceding tagging, coho salmon smolt were sorted into 3 size classes: small (75–84 mm FL), medium (85–99 mm FL), and large (≥100 mm FL). All healthy coho salmon smolt ≥75 mm FL were marked with an adipose fin clip and given a CWT following the methods in Koerner (1977). Fish were first tranquilized in a solution of tricain-methane sulfonate (MS 222) buffered with sodium bicarbonate.

Spring 2008 was the third year when Chilkat River juvenile coho salmon were differentially marked by size class. During April 11 – May 23, small fish were marked with tag code 04-13-73, and from May 25 – May 27 they were marked with tag code 04-15-07. These two codes were combined to represent fish in the small (75–84 mm FL) category. Medium and large fish (≥ 85mm) were marked with tag code 04-13-74 from April 11 – May 27. In an experimental analysis, statistical methods outlined in Weller et al. (2005) and discussed in Appendix B1, were used to test for size-based differences.

Table 1.–Peak survey counts and estimated escapement of coho salmon to the Chilkat River, 1987–2009. Escapement estimates in bold were estimated directly through mark-recapture studies (inriver abundance minus inriver harvest). All others were expanded from the combined peak surveys.

| | Peak surveys | | | | | Estimated | | |
|---|---|---|---|---|---|---|---|---|
| | Spring Creek | Kelsall River | Tahini River | Clear Creek | Combined ($C_t$) | escapement ($\hat{N}$) | SE ($\hat{N}$) | Estimation method |
| 1987 | 99 | 197 | 792 | 25 | 1,113 | 37,432 | 7,202 | expanded survey |
| 1988 | 87 | 160 | 590 | 40 | 877 | 29,495 | 5,675 | expanded survey |
| 1989 | 57 | 190 | 1,064 | 141 | 1,452 | 48,833 | 9,395 | expanded survey |
| 1990 | 88 | 379 | 2,766 | 150 | 3,383 | **79,807** | **9,980** | **mark-recapture** |
| 1991 | 176 | 417 | 1,785 | 135 | 2,513 | 84,517 | 16,260 | expanded survey |
| 1992 | 183 | 281 | 1,143 | 700 | 2,307 | 77,588 | 14,927 | expanded survey |
| 1993 | 101 | 129 | 1,041 | 460 | 1,731 | 58,217 | 11,200 | expanded survey |
| 1994 | 451 | 440 | 4,482 | 408 | 5,781 | 194,425 | 37,405 | expanded survey |
| 1995 | 268 | 197 | 1,033 | 189 | 1,687 | 56,737 | 10,916 | expanded survey |
| 1996 | 204 | 179 | 412 | 315 | 1,110 | 37,331 | 7,182 | expanded survey |
| 1997 | 227 | 133 | 684 | 250 | 1,294 | 43,519 | 8,373 | expanded survey |
| 1998 | 271 | 265 | 649 | 275 | 1,460 | **50,758** | **10,698** | **mark-recapture** |
| 1999 | 335 | 207 | 962 | 195 | 1,699 | 57,140 | 10,993 | expanded survey |
| 2000 | 305 | 571 | 1,324 | 435 | 2,635 | 88,620 | 17,050 | expanded survey |
| 2001 | 450 | 225 | 1,272 | 1,285 | 3,232 | 108,698 | 20,912 | expanded survey |
| 2002 | 1,328 | 440 | 2,582 | 1,310 | 5,660 | **205,429** | **31,165** | **mark-recapture** |
| 2003 | 500 | 356 | 1,419 | 1,675 | 3,950 | **134,340** | **15,070** | **mark-recapture** |
| 2004 | 564 | 170 | 827 | 445 | 2,006 | 67,465 | 12,980 | expanded survey |
| 2005 | 221 | 42 | 219 | 495 | 977 | **38,589** | **4,625** | **mark-recapture** |
| 2006 | 503 | 220 | 761 | 915 | 2,399 | 80,683 | 15,523 | expanded survey |
| 2007 | 55 | 51 | 415 | 237 | 758 | 25,493 | 4,905 | expanded survey |
| 2008 | 337 | 64 | 779 | 526 | 1,706 | 57,376 | 11,039 | expanded survey |
| 2009 | 183 | 159 | 429 | 682 | 1,453 | 48,867 | 9,402 | expanded survey |
| Mean | 304 | 238 | 1,193 | 491 | 2,225 | 74,407 | 14,399 | |
| | | | | | Expansion factor($\bar{\pi}$) | 33.6 | | |
| | | | | | SE($\pi_p$) | 6.5 | | |

All marked coho salmon smolt were held overnight to check for 24-hour tag retention and handling-induced mortality. The following morning, 100 fish from the previous day's marking effort were checked for the retention of CWTs. If tag retention was 98/100 or greater, mortalities were counted and all live fish from that batch were released. If tag retention was less than 98/100, then every smolt presumed to contain a CWT was checked for tag retention and those that tested negative were re-tagged. The number of fish tagged, number of tagging-related mortalities, and number of fish that had shed their tags were compiled and submitted to the ADF&G Commercial Fish Division (CF) Mark, Tag, and Age Laboratory in Juneau at the completion of the field season.

Every 60$^{th}$ coho salmon smolt tagged was measured to the nearest mm FL, weighed to the nearest gram, and 12 to 15 scales were collected for age analysis using methods outlined by Scarnecchia (1979). Scales were mounted individually between two 25 mm × 75 mm glass slides and viewed through a microfiche reader at 70× magnification. Age was estimated once for each fish and reported in European notation.

## LOWER RIVER ADULT SAMPLING

Returning coho salmon were captured in fish wheels operating adjacent to MP 9 (Figure 1) during 2009. CF personnel installed two 3-basket aluminum fish wheels in early June to estimate escapement of coho, sockeye *O. nerka*, Chinook *O. tshawytscha*, and chum salmon *O. keta*, to the Chilkat River. One fish wheel was operated adjacent to MP 9, and the other about 300 m downstream of the first. The fish wheels were operated continuously from June 10 through October 9, except for maintenance. The wheels were located along the east bank of the river where the main flow was constrained primarily to one side of the floodplain. Water depth (cm) and temperature (°C) were recorded each morning near MP 8.

Every captured coho salmon was inspected for missing adipose fins and sampled for sex determination and length (measured to the nearest 5 mm MEF). Coho salmon ≥350 mm MEF were assumed to be adults, for preliminary estimates of the marked fraction ($\theta_s$). Every third coho salmon was systematically sampled for scales. Five scales were removed from the left side of the fish, along a line 2 to 4 scale rows above the lateral line between the posterior insertion of the dorsal fin and anterior insertion of the anal fin. Ages were estimated according to methods in Mosher (1968).

Fish wheel personnel retained heads from all coho salmon with missing adipose fins, and a plastic cinch strap with a unique number was inserted through the jaw of the head. Fish with missing adipose fins were also sampled for scales to determine freshwater age composition of returning coded wire tagged fish. Heads and CWT recovery data were sent to the CF Mark, Tag, and Age Laboratory in Juneau where any tags present were removed and decoded; corresponding information was entered into the tag lab database.

## SMOLT ABUNDANCE

A two-event mark-recapture experiment was used to estimate the abundance of coho salmon smolt ($\hat{N}_s$) emigrating from Chilkat River in 2008. The number of smolt marked during spring 2008 defined the first sampling event. Sampling returning adults for missing adipose fins during fall 2009 defined the second sampling event.

The number of emigrating coho salmon smolt was estimated using the Chapman's modified Petersen estimator for a closed population (Seber 1982):

$$\hat{N}_s = \frac{(n_1+1)(n_2+1)}{(m_2+1)} - 1 \qquad (1a)$$

$$\mathrm{var}[\hat{N}_s] = \frac{(n_1+1)(n_2+1)(n_1 - m_2)(n_2 - m_2)}{(m_2+1)^2(m_2+2)} \qquad (1b)$$

where $n_1$ is the number of smolt marked in the spring of 2008, $n_2$ is the number of age-1.1 and -2.1 coho salmon captured in the Chilkat River fish wheels in 2009, and $m_2$ is the subset of $n_2$ that had been marked with an adipose fin clip as coho smolt in 2008. The marked fraction $\theta_s$ was calculated as $m_2/n_2$. Standard error for $\theta_s$ was calculated using standard methods for variance of proportions, because $m_2$ and $n_2$ were measured with certainty:

$$\mathrm{var}[\theta_s] = \frac{\theta_s(1-\theta_s)}{(n_2-1)}. \qquad (1c)$$

The validity of the Petersen mark-recapture experiment rests on several assumptions: (a) that every fish has an equal probability of being marked during event 1, that every fish has an equal probability of being captured in event 2, or that marked fish mix completely with unmarked fish; (b) that recruitment or "death" (emigration) do not occur disproportionately among marked and unmarked fish between sampling events; (c) that marking does not affect the ability to capture fish, or the probability of mortality; (d) that fish do not lose marks between sample events; (e) that all recovered marks are reported; and (f) that double sampling does not occur (Seber 1982).

Tagging smolt groups according to size allows for testing of assumption (a), which is violated by either different marking probabilities during event 1 or different capture probabilities in event 2. If significant differences in event 1 or 2 capture probability by size class are detected, an unbiased size-stratified smolt abundance estimator, based on Chapman's modification of the Peterson estimator (Appendix B; Seber 1982; Weller et al. 2005) could be used.

## ADULT HARVEST

In 2009, harvest of coho salmon originating from the Chilkat River was estimated by sampling for CWTs in commercial and recreational marine fisheries, and in the Chilkat River recreational fishery. To account for tag loss, the marked fraction relevant to the marine environment was calculated as $\theta_m$ = number of CWTs successfully decoded/$n_2$. The parameter $\theta_m$ is a subset of the ratio of adipose-clipped fish observed ($\theta_s$), and variance was calculated similarly to equation (1c).

The CF port sampling program sampled landings from commercial drift gillnet, set gillnet, purse seine, and troll fisheries throughout Southeast Alaska and Yakutat. During summer and early fall, samplers were stationed at processors in Ketchikan, Craig, Wrangell, Petersburg, Sitka, Pelican, Port Alexander, Elfin Cove, Excursion Inlet, and Juneau. The sample goal was to inspect at least 20% of the total catch of Chinook and coho salmon for missing adipose fins. Heads from fish missing their adipose fin were sent to the CF Mark, Tag, and Age Laboratory in Juneau on a weekly basis where CWTs were removed and decoded, and the resulting information compiled. The annual CF port sampling manual[1] provides a detailed explanation of commercial catch sampling procedures and logistics.

Methods used by ADF&G Division of Sport Fish (SF) creel surveys to sample recreational fisheries in Southeast Alaska are described in Hubartt et al. (1997). Chilkat River coho salmon CWTs recovered from sport fisheries in 2009 depend on creel survey sampling data for harvest estimation.

Because there was no consistent sampling in the Haines area, the estimated harvests of Chilkat River coho salmon in the Haines marine and Chilkat River sport fisheries came from the Statewide Harvest Survey (SWHS) produced by SF. SWHS estimates in all streams and tributaries within the Chilkat River drainage were summed to estimate the total inriver coho salmon harvest. Haines area marine sport fishery estimates were restricted to SWHS locations near the terminus of the Chilkat River, and all coho salmon harvested within these locations were assumed to be of Chilkat River origin.

[1] ADF&G (Alaska Department of Fish and Game). *Unpublished*. Coded wire tag sampling program detailed sampling instructions, commercial fisheries sampling, Located at Alaska Department of Fish and Game, Division of Commercial Fisheries, 802 3rd Street, Douglas, Alaska

Because several fisheries exploit coho salmon over several months, the 2009 harvest was estimated over several strata, each a combination of time, area, and type of fishery. Sampling data from the commercial troll fishery were stratified by statistical week and quadrant. Statistics from drift gillnet fisheries were stratified by week and district.

Data from the port sampling program were used to estimate the commercial harvest of coho salmon bound for the Chilkat River $\hat{r}_i$ and its variance (by stratum) using the procedures in Bernard and Clark (1996). Estimates of harvest were summed across strata and across fisheries to obtain an estimate of the total $\hat{T}$:

$$\hat{T} = \sum_i \hat{r}_i \tag{2a}$$

$$\mathrm{v}[\hat{T}] = \sum_i \mathrm{v}[\hat{r}_i] \tag{2b}$$

Variance was estimated as the sum of variances across strata because sampling was independent across strata and fisheries.

The mean date of harvest for a commercial fishery was estimated as (Mundy 1982):

$$\hat{\bar{d}} = \sum_{d=1}^{n} d\hat{P}_d \tag{3}$$

where $\hat{P}_d$ is the estimated proportion of harvest on day $d$:

$$\hat{P}_d = \frac{\hat{H}_d}{\sum_d H_d}$$

$$v\left(\hat{P}_d\right) = \frac{\hat{P}_d(1-\hat{P}_d)}{n-1} \tag{4}$$

where $\hat{H}_d$ is the estimated number of Chilkat River coho salmon harvested on day *d.*

## ADULT ESCAPEMENT

The 2009 coho salmon escapement to the Chilkat River was estimated by expanding the combined peak survey counts on 4 index spawning tributaries. The surveys were repeated weekly during the peak spawning period of October 1 to October 31. Five mark-recapture studies were compared to corresponding index counts to calculate a mean expansion factor (33.6, SE = 6.5), and validated that the peak survey counts are a good relative measure of coho escapement to the Chilkat River with the former surveyor (Ericksen 2006).While the current surveyor has not had a mark-recapture experiment to validate the accuracy of spawning grounds peak counts, methods are identical to the previous surveyor and it is assumed that counts are similar.

### Expansion for Peak Survey Counts

The ratio ($\hat{\pi}_i$) of abundance to peak survey counts for spawning Chilkat coho salmon in year *i* was:

$$\hat{\pi}_i = \hat{N}_i / C_i \tag{5a}$$

$$\mathrm{v}(\hat{\pi}_i) = \mathrm{v}(\hat{N}_i) / C_i^2 \tag{5b}$$

where $\hat{N}_i$ was the mark-recapture escapement estimate of coho salmon (inriver abundance minus inriver harvest) and $C_i$ was the total of peak survey counts for that year.

The mean ratio $(\overline{\pi})$ from the five years with mark-recapture estimates was used to expand peak survey counts in years *t* without such estimates:

$$\hat{N}_t = \overline{\pi}\ C_t \qquad (6a)$$

$$\mathrm{v}(\hat{N}_t) = C_t^2\ \mathrm{v}(\pi) \qquad (6b)$$

where

$$\overline{\pi} = \frac{\sum_{y=1}^{k} \hat{\pi}_y}{k} \qquad (7a)$$

Note that the variance of year *t*, $v(\pi)$, instead of average mark-recapture variance, $v(\overline{\pi})$, was used in equation 6b to capture the expected year-to-year variability in the expansion factor, while simultaneously accounting for measurement error from the mark-recapture experiments.

Estimating variance of the expansion of index counts also needs to reflect these two sources of variability for the prediction of π, represented by ($\pi_p$).The variance expression has 2 components, which reflect an estimate of process error and measurement error:

$$v\hat{a}r(\pi_p) = v\hat{a}r(\pi) + v\hat{a}r(\overline{\pi}) \qquad (7b)$$

The term $\mathrm{v\hat{a}r}(\pi)$ represents process error, i.e., error that is present through environmental variability or the population dynamics process. The term $\mathrm{v\hat{a}r}(\overline{\pi})$ represents the inter-annual uncertainty in predicting $\hat{\pi}$, or measurement error, which declines with every subsequent mark-recapture estimate of $\hat{\pi}$.

Expanding these two terms into variance terms that can be estimated yields the expressions:

$$v\hat{a}r(\hat{\pi}) = \frac{\sum_{y=1}^{k} (\hat{\pi}_y - \overline{\pi})^2}{k-1} \qquad (7c)$$

and,

$$v\hat{a}r(\overline{\pi}) = \frac{\sum_{y=1}^{k} (\hat{\pi}_y - \overline{\pi})^2}{k(k-1)} \qquad (7d)$$

Estimates of $var(\hat{\pi})$ and $var(\overline{\pi})$ were performed through a parametric bootstrap technique with 1,000,000 iterations as described in Efron and Tibshirani (1993). A bootstrap sample of size *k* is drawn from the *k* values of the individual estimates of $\hat{\pi}_y$ to produce a set of values represented by $\hat{\pi}_{y(b)}$.The bootstrap mean, $\overline{\pi}_{(b)}$, of these values is used to estimate $var(\hat{\pi})$ using these relationships:

$$v\hat{a}r_B(\hat{\pi}) = \frac{\sum_{b=1}^{B} (\hat{\pi}_{(b)} - \overline{\hat{\pi}_{(b)}})^2}{B-1} \qquad (7e)$$

where

$$\overline{\hat{\pi}_{(b)}} = \frac{\sum_{b=1}^{B} \hat{\pi}_{(b)}}{B} \qquad (7f)$$

Calculating $var_B(\overline{\pi})$ uses equations 7e and 7f by substituting appropriate terms. The overall variance of expansion factor prediction combined the bootstrap estimates, with the average of estimated variance of the individual expansion terms $\hat{\pi}_y$, to yield the result:

$$v\hat{a}r(\pi_p) = v\hat{a}r_B(\hat{\pi}) - \frac{\sum_{y=1}^{k} \text{v}\hat{\text{a}}\text{r}(\hat{\pi}_y)}{k} + v\hat{a}r_B(\overline{\pi}) \qquad (7g)$$

## AGE, SEX, AND SIZE COMPOSITIONS

Age composition of coho salmon smolt in 2008 and age and sex compositions of adults in 2009 were estimated from systematically drawn samples as described above. Standard sample summary statistics were used to calculate estimates of mean length- and mean weight-at-age and their variances (Cochran 1977). Proportions in the age (or sex) compositions and their variances were estimated as:

$$\hat{p}_a = \frac{n_a}{n} \qquad (8a)$$

$$\text{v}[\hat{p}_a] = \frac{\hat{p}_a\ (1 - \hat{p}_a)}{n - 1} \qquad (8b)$$

where $n$ is the number of successfully aged (or sexed) fish and $n_a$ is the subset of $n$ determined to be age (or sex) $a$.

The abundance of sex $x$ coho salmon in the escapement was estimated as:

$$\hat{N}_x = \hat{N}_e\ \hat{p}_x \qquad (9a)$$

$$\text{v}[\hat{N}_x] = \text{v}[\hat{p}_x]\hat{N}_e^{\,2} + \text{v}[\hat{N}_e]\hat{p}_x^{\,2} - \text{v}[\hat{p}_x]\text{v}[\hat{N}_e] \qquad (9b)$$

where $\hat{N}_e$ is the estimated escapement of coho salmon in 2009. The abundance of age $a$ coho salmon by sex in the escapement $\hat{N}_{x,a}$ was estimated by substituting $\hat{N}_x$ and $\hat{p}_{x,a}$ for $\hat{N}_e$ and $\hat{p}_x$ in equations 9a and 9b.

## RUN SIZE, EXPLOITATION RATE, AND MARINE SURVIVAL

In 2009, the Chilkat River coho salmon return (harvest plus escapement) was estimated as:

$$\hat{N}_R = \hat{T} + \hat{N}_e \qquad (10a)$$

$$\text{v}\left[\hat{N}_R\right] = \text{v}\left[\hat{T}\right] + \text{v}\left[\hat{N}_e\right] \qquad (10b)$$

The fraction of the run harvested (the exploitation rate) was calculated as:

$$\hat{E} = \frac{\hat{T}}{\hat{N}_R} \qquad (11a)$$

$$v[\hat{E}] \approx \frac{v[\hat{T}]\hat{N}_e^2}{\hat{N}_R^4} + \frac{v[\hat{N}_e]\hat{T}^2}{\hat{N}_R^4} \qquad (11b)$$

where the variance is an approximation from the delta method (Seber 1982).

The estimated marine survival rate (smolt-to-adult) and the delta method approximation of its variance were calculated as:

$$\hat{S} = \frac{\hat{N}_R}{\hat{N}_s} \qquad (12a)$$

$$v[\hat{S}] \approx \hat{S}^2 \left[ \frac{v[\hat{N}_R]}{\hat{N}_R^2} + \frac{v[\hat{N}_s]}{\hat{N}_s^2} \right] \qquad (12b)$$

# RESULTS

## 2008 Smolt Tagging, Age and Size

During spring 2008, 23,165 coho salmon smolt ≥75 mm FL were marked with an adipose fin clip and a CWT (Table 2). One hundred six (106) of these died within 24 hours of tagging, leaving a total marked population of 23,059. In a concurrent study, 2,499 Chinook salmon were released with adipose fin clips and CWTs (Table 3).

Table 2.–Summary of coded wire tagging data in the Chilkat River drainage during spring 2008. CWT = coded wire tag.

| Tag code | Species | Last date | Tagged | 24-hour mortalities | Marked | Shed tags | Valid CWTs |
|---|---|---|---|---|---|---|---|
| 041373 | coho | 5/24/2008 | 11,067 | 33 | 11,034 | 0 | 11,034 |
| 041374 | coho | 5/28/2008 | 11,241 | 58 | 11,183 | 0 | 11,183 |
| 041507 | coho | 5/28/2008 | 857 | 15 | 842 | 0 | 842 |
| Total | | | 23,165 | 106 | 23,059 | 0 | 23,059 |

Table 3.–Number of traps checked and smolt caught, tagged, and released in the Chilkat River by time period, April 10 through May 27, 2008.

| | Chilkat River | | | | |
|---|---|---|---|---|---|
| | Traps | Number tagged | | CPUE[a] | |
| Dates | checked | Coho | Chinook | Coho | Chinook |
| 4/10–4/16 | 562 | 2,163 | 229 | 3.8 | 0.4 |
| 4/17–4/23 | 667 | 2,784 | 313 | 4.2 | 0.5 |
| 4/24–4/30 | 688 | 3,475 | 526 | 5.1 | 0.8 |
| 5/1–5/7 | 691 | 3,119 | 651 | 4.5 | 0.9 |
| 5/8–5/14 | 698 | 3,109 | 614 | 4.5 | 0.9 |
| 5/15–5/21 | 694 | 4,776 | 160 | 6.9 | 0.2 |
| 5/22–5/27 | 598 | 3,633 | 6 | 6.1 | 0.0 |
| Total | 4,598 | 23,059 | 2,499 | 5.0 | 0.5 |

[a] Catch of smolt per trap day.

Spring arrived late in 2008, causing below-average minnow trap catches and peak catches to occur towards the end of the project. In April the Chilkat River water temperature was below average, resulting in low catches and a below-average CPUE (5.0, Table 3). The Chilkat River water level did not rise substantially until mid May; consequently the daily catch of coho salmon smolt did not peak until May 23 (Figure 2), compared to an average of May 12. The average weekly CPUE peaked May 15–21 at 6.9 fish per trap (Table 3).

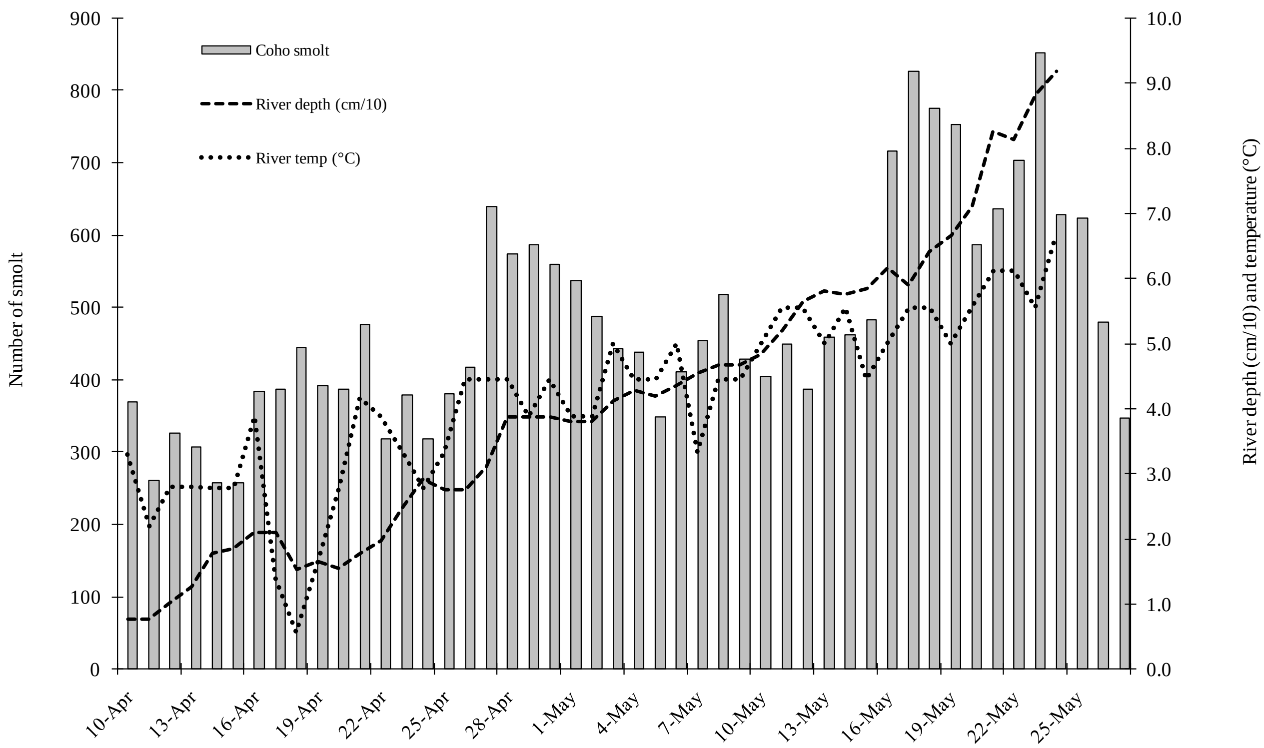


Figure 2.–Catches of coho salmon smolt ≥75 mm, daily water temperature ($^{o}$C), and depth (cm/10), in the Chilkat River, April 10 through May 27, 2008.

During spring 2008, 391 coho salmon smolt ≥75 mm were sampled from the Chilkat River for age, weight and length (Table 4). Of the 389 Chilkat River scale samples successfully aged, age-1. fish comprised the majority of the smolt emigration (86.6%, SE = 1.7%). Overall, coho salmon smolt weighed 7.1 g (SE = 2.9 g) and averaged 88.1 mm FL (SE = 11.1 mm; Table 4). CF personnel, as part of a concurrent study, captured 3,090 coho salmon smolt emigrating out of Chilkat Lake from May 28 through June 11, 2008. A total of 192 were sampled for age, weight, and length, and 183 of those samples were successfully aged (Table 4). Smolt sampled at Chilkat Lake were significantly older than those sampled from the Chilkat River (42.1% vs. 13.4% age 2; $\chi^2 = 58.7$, df = 1, $P < 0.001$). Chilkat Lake smolt were also larger on average (115 mm, 15.4 g) than those sampled from the Chilkat River (88 mm, 7.1 g).

Table 4.–Estimated age and size composition of coho salmon smolt ≥75 mm FL marked in the Chilkat River, including coho salmon smolt sampled at Chilkat Lake, 2008.

| | | Age-1 | Age-2 | Total aged | Total sampled |
|---|---|---|---|---|---|
| Chilkat River | sample size | 337 | 52 | 389 | 391 |
| | percent (SE) | 86.6 (1.7) | 13.4 (1.7) | | |
| | mean length (SE) | 85.4 (8.3) | 105.9 (10.1) | | 88.1 (11.1) |
| | mean weight (SE) | 6.4 (2.0) | 11.7 (3.9) | | 7.1 (2.9) |
| Chilkat Lake[a] | sample size | 106 | 77 | 183 | 192 |
| | percent (SE) | 57.9 (3.7) | 42.1 (3.7) | | |
| | mean length (SE) | 111.2 (6.4) | 121.4 (8.7) | | 115.5 (9.0) |
| | mean weight (SE) | 14.0 (2.6) | 17.3 (4.0) | | 15.4 (3.6) |

[a] Division of Commercial Fisheries personnel sampled coho salmon smolt at the Chilkat Lake weir from May 28 to June 11, 2008.

## 2009 Lower River Adult Sampling

From July 14 through October 9 2009, a total of 2,031 adult coho salmon were captured in the fish wheels (Figure 3), of which 1,996 were examined for missing adipose fins; 1,940 were 350 mm FL or greater and were assumed to be ocean age-1 fish. Sixty-two (62) fish were missing an adipose fin, and their heads were examined for CWTs (Table 5). Sixty (60) heads contained decodable tags that were released in the Chilkat River in 2008. Two fish with missing adipose fins did not contain tags.

Scale samples were collected from 933 coho salmon and 818 were successfully aged. Of these, 98.0% were age-1.1 or -2.1 (ocean age-1; Table 6). Applying the ocean age-1 proportion to all sampled fish, an estimated 1,957 adults sampled for missing adipose fins in 2009 emigrated as smolt during 2008.

Table 5.–Number of age -.1 adult coho salmon sampled in the lower Chilkat River for missing adipose fins and coded wire tags, 2009.

| | | Tag code | | | | | |
|---|---|---|---|---|---|---|---|
| Statistical week | Number sampled | 04-13-73 | 04-13-74 | 04-15-07 | No tag | Total adipose fin clips | Proportion marked |
| 29 | 1 | | | | | 0 | 0.000 |
| 32 | 1 | | | | | 0 | 0.000 |
| 33 | 8 | | | | | 0 | 0.000 |
| 34 | 20 | | 1 | | | 1 | 0.050 |
| 35 | 64 | | 1 | | | 1 | 0.016 |
| 36 | 138 | 2 | 4 | | 1 | 7 | 0.051 |
| 37 | 321 | 5 | 5 | | | 10 | 0.031 |
| 38 | 447 | 8 | 5 | | | 13 | 0.029 |
| 39 | 610 | 7 | 11 | | 1 | 19 | 0.031 |
| 40 | 269 | 5 | 3 | | | 8 | 0.030 |
| 41 | 78 | 1 | 2 | | | 3 | 0.038 |
| Total | 1,957 | 28 | 32 | 0 | 2 | 62 | 0.032 |

Table 6.–Combined first and second half stratified estimates for the sampled age/sex composition and length of coho salmon captured in the fish wheels, and estimated escapement in the Chilkat River, 2009.

| | Brood year and age class | | | | | |
|---|---|---|---|---|---|---|
| | 2007 | 2006 | 2006 | 2005 | | |
| | 1.0 | 2.0 | 1.1 | 2.1 | Total aged | Total sampled[a] |
| **Females** | | | | | | |
| Sample size | | | 266 | 61 | 327 | 790 |
| Percent | | | 32.5 | 7.5 | | 38.9 |
| SE | | | 1.6 | 0.9 | | 1.1 |
| Number | | | 15,967 | 3,714 | | 19,681 |
| SE | | | 2,680 | 785 | | 3,091 |
| Mean length | | | 604 | 643 | | |
| SD | | | 56 | 49 | | |
| **Males** | | | | | | |
| Sample size | 1 | 15 | 416 | 59 | 491 | 1,232 |
| Percent | 0.1 | 1.8 | 50.9 | 7.2 | | 60.7 |
| SE | | 0.5 | 1.7 | 0.9 | | 1.1 |
| Number | 57 | 891 | 24,678 | 3,560 | | 29,186 |
| SE | 0 | 265 | 4,093 | 727 | | 4,727 |
| Mean length | 275 | 308 | 558 | 601 | | |
| SD | | 14 | 105 | 85 | | |
| **All fish[b]** | | | | | | |
| Sample size | 1 | 15 | 682 | 120 | 818 | 2,031 |
| Percent | 0.1 | 1.8 | 83.4[c] | 14.7[c] | | |
| SE | | 0.5 | 1.3 | 1.2 | | |
| Number | 57 | 891 | 40,645 | 7,274 | | 48,867 |
| SE | | 265 | 4,892 | 1,070 | | 11,039 |
| Mean length | 275 | 308 | 576 | 623 | | |
| SD | | 14 | 92 | 72 | | |

[a] Includes fish not assigned an age.
[b] Includes fish with no sex information.
[c] Actual proportions are 0.8337 and 0.1467, respectively.

## SMOLT ABUNDANCE

Using Chapman's modified Petersen estimator for a closed population (Seber 1982), the 2008 Chilkat River coho salmon smolt abundance estimate was 716,689 (SE = 88,013). This estimate is based on $n_1$ = 23,059 smolt released in spring 2008, $n_2$ = 1,957 ocean-age-1 adults sampled from the fish wheels in 2009, and a total of $m_2$ = 62 valid-marked fish recovered inriver (60 with 2008 Chilkat River tag codes and 2 missing or non-valid tags). The estimated marked fraction $\theta_s$ relevant to calculating smolt abundance was 0.032 (SE = 0.004).

Using $\chi^2$ testing, a significant difference was detected in recovery rates between 2 distinct tagging groups (Table 7). Group 1 was smolt 75–84 mm FL and given tag codes 04-13-73 and 04-15-07, while group 2 was smolt ≥85 mm FL, and given code 04-13-74. Overall 11,876 coho salmon smolt were released in group 1; 118 CWTs were recovered in fisheries, and 28 CWTs were recovered in lower Chilkat River sampling, for a total of 146. In group 2, 11,183 coho salmon smolt were released; 207 were recovered in fisheries, and 32 were recovered in lower river sampling for a total of 239. A 2 x 2 contingency table revealed a significant difference in recovery rates for these two tagging groups ($\chi^2$ = 25.7, df = 1, P < 0.001).

Table 7.–Comparison of coded wire recoveries for 2 classes of coho smolt sizes tagged in the Chilkat River in 2008. Tag codes 041373 and 041507 were used for smolt 75–84 mm, and tag code 041374 was used for smolt ≥85 mm; chi-square tests show significant difference at alpha = 0.10 between the two size groups.

| Tag code | | | Chi-square tests of independence | |
|---|---|---|---|---|
| Tag code 04-13-73 an 04-15-07 (75–84mm) | | | 2 X 2 contingency table | |
| number tagged (*N1*) | | 11,876 | *N1* | *N2* |
| recovered in fisheries | | 118 | 11,876 | 11,183 |
| recovered in fish wheels | | 28 | 146 | 239 |
| total recoveries | | 146 | | |
| | survival rate 1 ($S_1$) = | 0.0123 | $X^2$ = 27.95, df = 1, P < 0.001 | |
| | | | | |
| Tag code 04-13-74 (≥85 mm) | | | | |
| number tagged (*N2*) | | 11,183 | | |
| recovered in fisheries | | 207 | | |
| recovered in fish wheels | | 32 | | |
| total recoveries | | 239 | | |
| | survival rate 2 ($S_2$) = | 0.0214 | | |
| | survival rate ratio (*B*) = | 1.738 | | |

The recovery rate (B) for larger coho salmon smolt was 1.74 times the rate for smaller smolt. The alternate smolt abundance estimator (Appendix B1), used to eliminate bias introduced by significantly different recovery rates, could not be used because insufficient age information was collected from adipose-finclipped fish captured in the Chilkat River fish wheels. Because fish were systematically sampled, ages from only 27 of the 62 adipose-finclipped fish were obtained. All of these 27 samples were freshwater-age-1 coho salmon. Therefore, comparisons of age proportions between the adult and smolt populations were not possible.

## CODED WIRE TAG RECOVERY

In 2009, 325 CWTs with Chilkat River codes were recovered from coho salmon during the random sampling of commercial marine harvests (Table 8, Appendix A1). Most tags (198) were recovered in the drift gillnet fisheries, followed by 123 recoveries in the commercial troll fisheries (Table 8). There were 3 recoveries in the inside purse seine fishery and one recovery in marine sport fisheries. There was also 1 select recovery from the Chilkat River subsistence fishery bearing a 2008 Chilkat River code (Appendix A1). Coho salmon bearing Chilkat River tag codes were recovered with comparable relative frequencies in the District 115 (Lynn Canal) drift gillnet fishery from August 18 to October 7, and in the Northwest Quadrant troll fishery from July 19 through September 24 ($\chi^2$ = 0.21, df = 2, P = 0.90, Table 8).

## HARVEST

The tagged fraction $\theta_m$, used for estimating marine harvest contributions, was 0.031 (SE = 0.004). This estimate is based on 60 Chilkat River CWTs decoded out of the heads collected from 62 adipose-finclipped fish, among the 1,957 1-ocean adult coho salmon inspected for marks in the Chilkat River in 2009.

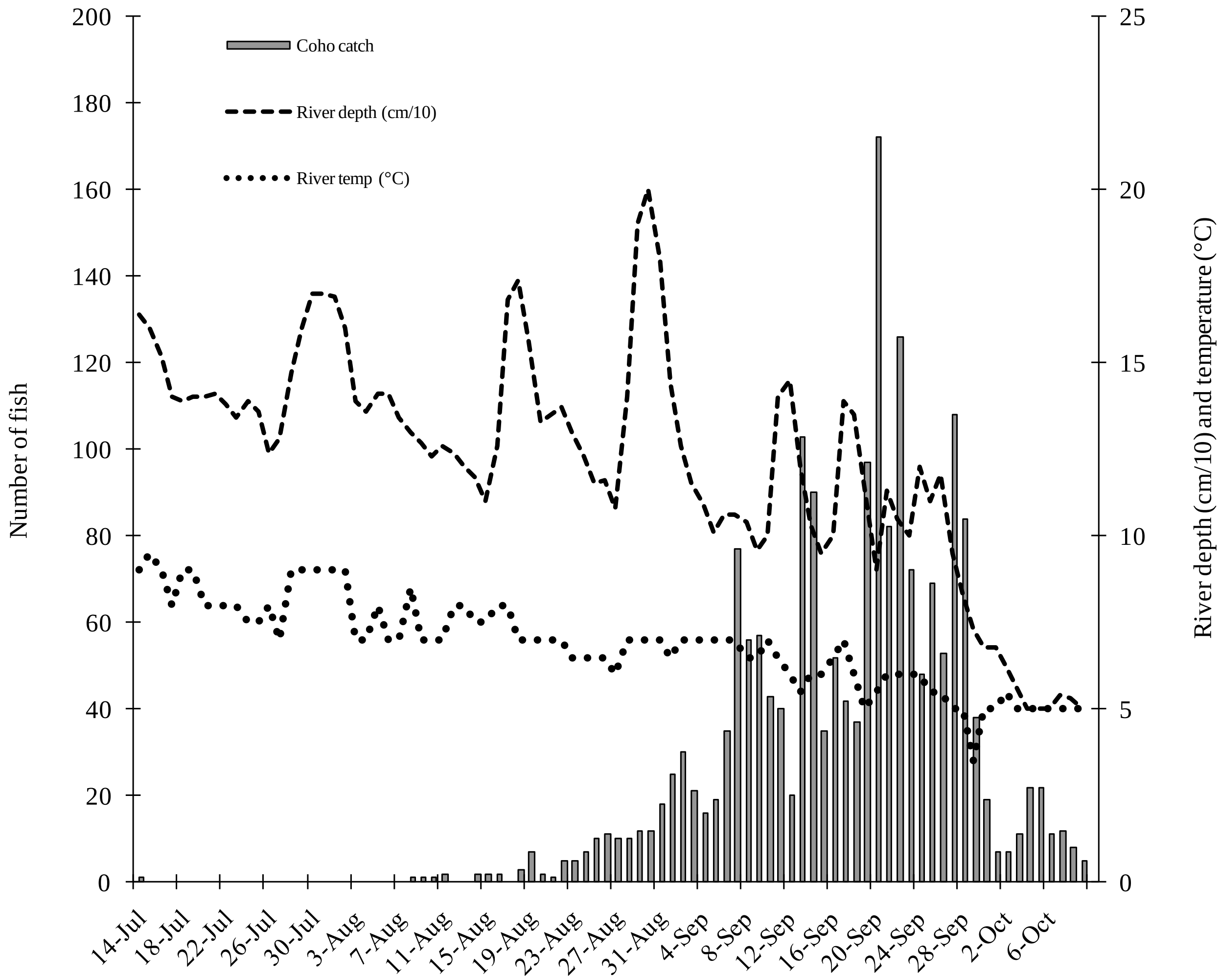


Figure 3.–Fish wheel catch of adult coho salmon, daily water depth (cm/10), and temperature ($^{o}$C) in the lower Chilkat River, July 14 through October 9, 2009.

An estimated 30,428 (SE = 2,585) Chilkat River coho salmon were harvested in sampled marine commercial and recreational fisheries in 2009 (Table 9). An additional 460 coho salmon were harvested in the Chilkat Inlet and Chilkat River subsistence fisheries, an estimated 2,059 (SE = 421) in Chilkat River recreational fisheries, and an estimated 35 (SE = 25) in Haines marine recreational fisheries, for a total harvest of 32,982 (SE = 2,619, Table 10). Most of the Chilkat River coho salmon harvest (46.0%; 15,179, SE = 1,437) occurred in the District 115 commercial drift gillnet fishery, followed by commercial troll fisheries (45.2%; 14,911, SE = 2,141). The remainder of the harvest occurred in the recreational (6.5%) and subsistence (1.4%) fisheries. Harvests in the troll fisheries occurred earlier in the year (July), due to the migration route from Gulf of Alaska feeding grounds to the Chilkat River (Figures 4 and 5), and covered a period of 10 weeks during the migration (Table 8). In contrast, harvest in the drift gillnet fisheries occurred over 8 weeks, from mid August through the first week of October. The estimated mean date of harvest in the Northwest Quadrant troll fishery was August 31 compared to September 18 for the Lynn Canal drift gillnet fishery.

Table 8.–Random marine recoveries of coded wire tags from Chilkat River coho salmon by tag code, fishery, and gillnet statistical week or troll period, 2009.

| Statistical | | Tag code | | | |
|---|---|---|---|---|---|
| week | Dates | 04-13-73 | 04-15-07 | 04-13-74 | Total |
| District 115 gillnet fishery | | | | | |
| 34 | 8/16–8/22 | 1 | | | 1 |
| 35 | 8/23–8/29 | 1 | | 4 | 5 |
| 36 | 8/30–9/5 | 8 | | 11 | 19 |
| 37 | 9/6–9/12 | 14 | | 25 | 39 |
| 38 | 9/13–9/19 | 12 | | 19 | 31 |
| 39 | 9/20–9/26 | 13 | 2 | 35 | 50 |
| 40 | 9/27–10/3 | 14 | | 20 | 34 |
| 41 | 10/4–10/9 | 8 | | 11 | 19 |
| | Gillnet subtotal | 63 | 2 | 114 | 198 |
| Northwest Quadrant troll fishery | | | | | |
| 30 | 7/19–7/25 | 1 | | 1 | 2 |
| 31 | 7/26–8/1 | 1 | | 1 | 2 |
| 32 | 8/2–8/8 | 7 | | 2 | 9 |
| 33 | 8/9–8/15 | 2 | | 6 | 8 |
| 34 | 8/16–8/22 | 8 | | 2 | 10 |
| 35 | 8/23–8/29 | 9 | | 15 | 24 |
| 36 | 8/30–9/5 | 10 | | 17 | 27 |
| 37 | 9/6–9/12 | 4 | | 23 | 27 |
| 38 | 9/13–9/19 | | | 10 | 10 |
| 39 | 9/20–9/26 | | | 3 | 3 |
| Southwest Quadrant troll fishery | | | | | |
| 36 | 8/30–9/5 | 1 | | | 1 |
| | Troll subtotal | 43 | 0 | 80 | 123 |
| District 112 purse seine fishery | | | | | |
| 34 | 8/1– 8/22 | 1 | 2 | | 3 |
| | Purse seine subtotal | 1 | 2 | 0 | 3 |
| Elfin Cove sport fishery | | | | | |
| 36 | 8/30–9/5 | | 1 | | 1 |
| | Marine sport subtotal | 0 | 1 | 0 | 1 |
| Total recoveries | | 107 | 5 | 194 | 325 |
| Valid tags released | | 11,034 | 842 | 11,183 | 23,059 |
| Percent gillnet | | 59 | 40 | 59 | 61 |
| Percent troll | | 40 | 0 | 41 | 38 |

Table 9.–Estimated marine harvest in 2009 of adult coho salmon bound for the Chilkat River, by fishery and temporal stratum (sport period or commercial statistical week).

| Fishery | District | Statistical week | Harvest | Var[$N$] | $n$ | $a$ | $a'$ | $t$ | $t'$ | $m$ | $r$ | SE[$r$] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NW troll period 3 | | 27–33 | 379,745 | | 115,873 | 1,343 | 1,320 | 997 | 996 | 21 | 2,238 | 514 |
| NW troll period 4 | | 34–37 | 327,675 | | 117,057 | 1,713 | 1,680 | 1,384 | 1,381 | 88 | 8,639 | 1,120 |
| NW troll period 5 | | 38–40 | 71,779 | | 20,116 | 433 | 389 | 303 | 302 | 13 | 3,976 | 1,750 |
| SW troll period 4 | | 34–37 | 25,980 | | 15,148 | 307 | 297 | 221 | 220 | 1 | 58 | 58 |
| Troll subtotal | | | 805,179 | | 268,194 | 3,796 | 3,686 | 2,905 | 2,899 | 123 | 14,911 | 2,141 |
| Purse Seine | 112 | 34 | 5,605 | | 1,823 | 30 | 30 | 26 | 26 | 3 | 301 | 176 |
| Purse seine subtotal | | | 5,605 | | 1,823 | 30 | 30 | 26 | 26 | 3 | 301 | 176 |
| District 113 Sport | 113 | 17 | 290 | 52,665 | 255 | 7 | 7 | 4 | 4 | 1 | 37 | 37 |
| Sport subtotal | | | 290 | 52,665 | 255 | 7 | 7 | 4 | 4 | 1 | 37 | 37 |
| Lynn Canal gillnet | 115 | 34 | 602 | | 120 | 1 | 1 | 1 | 1 | 1 | 164 | 163 |
| Lynn Canal gillnet | 115 | 35 | 1,794 | | 539 | 10 | 10 | 10 | 10 | 5 | 543 | 250 |
| Lynn Canal gillnet | 115 | 36 | 2,083 | | 1,443 | 30 | 30 | 30 | 29 | 19 | 925 | 242 |
| Lynn Canal gillnet | 115 | 37 | 4,147 | | 2,485 | 64 | 62 | 59 | 59 | 39 | 2,191 | 452 |
| Lynn Canal gillnet | 115 | 38 | 6,967 | | 1,839 | 48 | 48 | 48 | 48 | 31 | 3,831 | 850 |
| Lynn Canal gillnet | 115 | 39 | 9,306 | | 3,632 | 118 | 115 | 107 | 107 | 50 | 4,288 | 827 |
| Lynn Canal gillnet | 115 | 40 | 5,850 | | 2,808 | 78 | 78 | 73 | 73 | 34 | 2,310 | 497 |
| Lynn Canal gillnet | 115 | 41 | 2,006 | | 1,340 | 23 | 23 | 21 | 21 | 19 | 928 | 243 |
| Gillnet subtotal | | | 32,755 | | 14,206 | 372 | 367 | 349 | 348 | 198 | 15,179 | 1,437 |
| | Total | | 843,829 | 52,665 | 284,478 | 4,205 | 4,090 | 3,284 | 3,277 | 325 | 30,428 | 2,585 |

Table 10.–Total (marine and freshwater) harvest and estimated Chilkat River harvest of coho salmon in Alaska fisheries, by fishery and area, 2009.

| | | Coho salmon harvest | | | Percent of harvest | |
|---|---|---|---|---|---|---|
| Fishery | Area | Total | Chilkat | SE | Fishery | Chilkat |
| Drift gillnet | District 115 | 32,755 | 15,179 | 1,437 | 46.3 | 46.0 |
| | Subtotal | 32,755 | 15,179 | 1,437 | 46.3 | 46.0 |
| Seine fishery | District 112 | 5,605 | 301 | 176 | 5.4 | 0.9 |
| | Subtotal | 5,605 | 301 | 176 | 5.4 | 0.9 |
| U.S. troll fishery | NW Quadrant | 779,199 | 14,853 | 2,141 | 1.9 | 45.0 |
| | SW Quadrant | 25,980 | 58 | 58 | 0.2 | 0.2 |
| | Subtotal | 805,179 | 14,911 | 2,141 | 1.9 | 45.2 |
| Recreational | District 113 Sport | 290 | 37 | 37 | 12.8 | 0.1 |
| | Haines marine[a] | 339 | 35 | 25 | 10.3 | 0.1 |
| | Chilkat River[a] | 2,059 | 2,059 | 421 | 100.0 | 6.2 |
| | Subtotal | 2,688 | 2,131 | 423 | 79.3 | 6.5 |
| Subsistence | Chilkat Inlet[b] | 95 | 95 | 0 | 100.0 | 0.3 |
| | Chilkat River[b] | 365 | 365 | 0 | 100.0 | 1.1 |
| | Subtotal | 460 | 460 | 0 | 100.0 | 1.4 |
| Total | | 846,687 | 32,982 | 2,619 | 3.9 | 100.0 |

[a] Estimates from the Statewide Harvest Survey.
[b] Subsistence harvests as reported on returned permits.

## ESCAPEMENT

A total of 1,453 coho salmon were counted during peak surveys in the Chilkat River drainage in 2009 (Table 1). Expansion factors for peak survey counts from past years, when mark-recapture was used to estimate inriver abundance, ranged from 23.6 (SE = 2.9) in 1990 to 39.5 (SE = 4.7) in 2005. The mean expansion factor 33.6 (SE = 6.5) was used to estimate that 48,867 (SE = 9,402) coho salmon reached spawning areas in the Chilkat River in 2009 (Table 1).

## AGE AND SEX COMPOSITION OF THE ESCAPEMENT

There was a significant difference in age composition between the first half of the immigration (prior to September 20; the median date of the fish wheel catch) and second half ($\chi^2 = 17.6$, df = 1, $P < 0.001$). There were also significant differences in age composition over time for males ($\chi^2 = 9.1$, df = 1, $P = 0.002$) and for females ($\chi^2 = 6.2$, df = 1, $P = 0.013$). Sex compositions also varied significantly over time for age-1.1 fish ($\chi^2 = 13.5$, df = 1, $P < 0.001$). Because of these differences, the samples were temporally stratified to estimate the age and sex composition of the escapement (Appendices A2 and A3). Age 1.1 males comprised 59.0% (SE = 2.4%) of the sample in the first half and 41.7% (SE = 2.5%) in the second half. Comparing temporal proportions of females, age-1.1 females comprised 28.9% (SE = 2.2%) in the first half of the sample, and 36.5% (SE = 2.5%) in the second half of the sample. Similarly, age-2.1 females comprised 4.2% (SE=1.0%) in the first half of the sample compared to 11.1% (SE=1.6%) in the second half of the sample. Overall, males comprised 60.7% (SE = 1.1%), and age-1.1 fish comprised 83.4% (SE = 1.3%) of the escapement (Table 6).

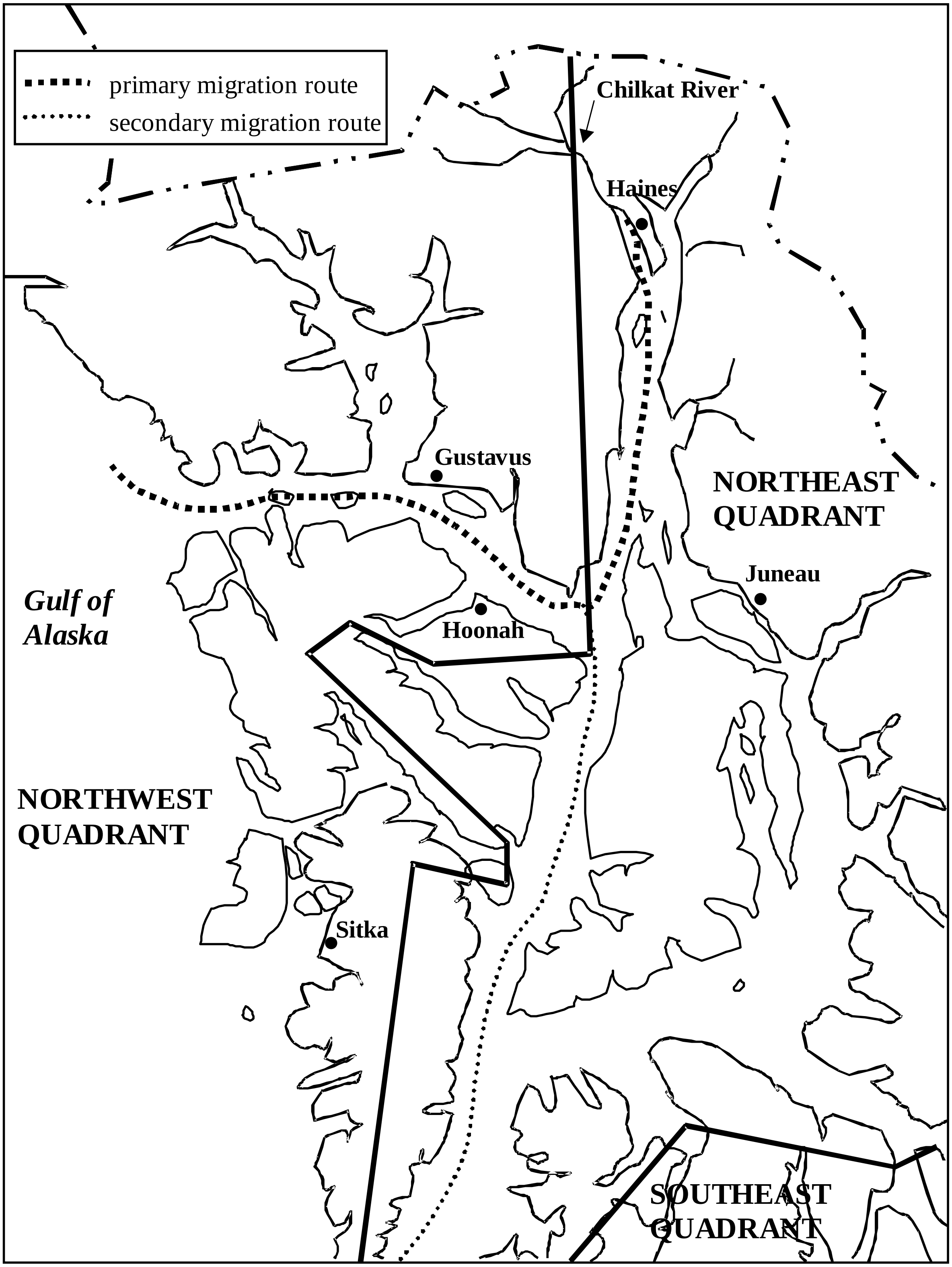


Figure 4.–Commercial troll quadrants and migration routes of Chilkat River coho salmon through northern Southeast Alaska.

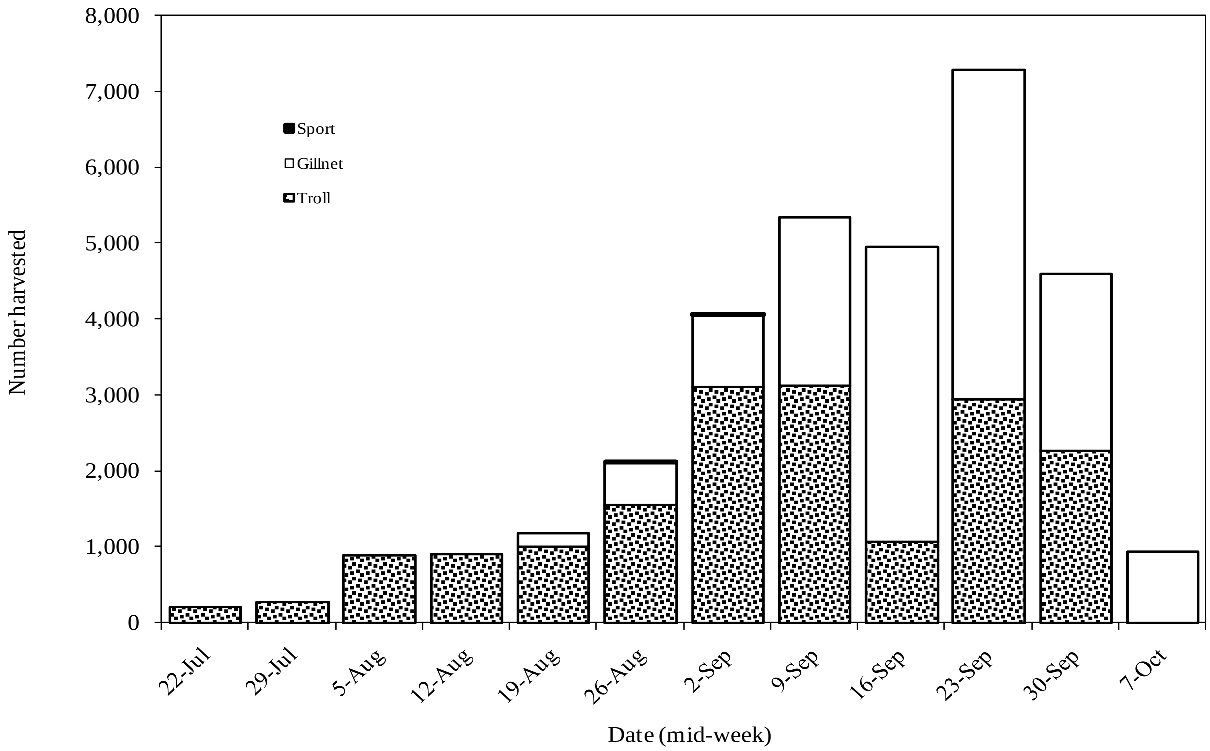


Figure 5.–Estimated marine harvests of coho salmon bound for the Chilkat River, by fishery and statistical week, 2009. Weekly estimates of harvest in marine sport fisheries (bi-week) are approximated.

## MARINE EXPLOITATION AND SURVIVAL

The total ocean age-.1 component of the estimated escapement was 47,911 fish (SE = 9,219, Table 11). Assuming all 30,558 fish harvested in marine fisheries and 2,424 fish harvested in inriver fisheries in 2009 (Tables 9 and 10) were age-.1, the total 2009 return of age-.1 Chilkat River coho salmon was 80,893 fish (SE = 9,584). The estimated marine survival rate for 2008 emigrants was 11.3% (SE = 1.9%). The marine exploitation of this stock was estimated at 37.8% (SE = 4.7%).

Table 11.–Estimated stock assessment parameters for coho salmon that emigrated from the Chilkat River in 2008.

| Parameter | Estimate | SE |
|---|---|---|
| 2008 smolt emigration | 716,689 | 88,013 |
| 2009 marine harvest | 30,558 | 2,585 |
| 2009 inriver harvest[a] | 2,424 | 421 |
| 2009 1-ocean age escapement[b] | 47,911 | 9,219 |
| Total 2009 return | 80,893 | 9,584 |
| Marine exploitation rate, % | 37.8 | 4.7 |
| Marine survival, % | 11.3 | 1.9 |

[a] Includes Haines marine recreational from the Statewide Harvest Survey and Chilkat Inlet subsistence.

[b] Total escapement excluding age-1.0 and -2.0 coho salmon.

# DATA FILES

Data collected during this study (Appendix C1) have been archived in ADF&G offices in Haines, Douglas, and Anchorage.

# DISCUSSION

The estimate of smolt abundance satisfies the several mark-recapture assumptions discussed above. Attempts were made to ensure every smolt had an equal chance of being marked. Although smolt were still being captured when trapping ceased on May 27, catch rates were declining from the peak. Therefore, the majority of the emigration was probably sampled. In addition, sampling effort for adults in the fish wheels (to estimate the marked fraction) was relatively constant over time, tending to equalize probability of capture during the second sampling event. Comparing CWT recovery rates for different coho salmon smolt size categories (Table 7) revealed a significant difference between groups (assumption a), and an alternate smolt estimator can be used to eliminate bias resulting from unequal sampling probabilities (Appendix B1). Smaller smolt were marked at a higher rate than larger smolt (Table 4 and 6), and larger smolt have a higher survival rate, so that the estimated marking fraction was biased low. The 2008 smolt estimate, therefore, was biased high which underestimates marine survival. Because insufficient age data exists from adult coho salmon tagged in 2008, the Chapman’s modified Peterson estimator was used.

Although the population in this experiment was not closed to losses from mortality, it was essentially closed to recruitment (assumption b) because salmon return to their natal stream to spawn. There have been rare instances when coho salmon with Berners River tags have been recovered in the Chilkat River (Ericksen 1999; Ericksen and Chapell 2005; Elliott 2010, 2011), or when juvenile coho salmon containing Chilkat River tags have been captured in other drainages. The most recent example of the former occurred in 2008, when a returning adipose-fin-clipped adult coho salmon captured in the Chilkat River fish wheels had a Berners River CWT released in 2007. This fish could either have strayed as an adult or more likely was of Chilkat River origin, and reared for some period of time in the Berners River where it was captured and tagged.

In addition to adult recoveries, a juvenile coho salmon with a Chilkat River tag code was captured moving upstream into Auke Creek near Juneau (Ericksen and Chapell 2005). This was the first time that a juvenile Chilkat River fish was captured migrating *upstream* into another drainage in the fall. However, smolt with Chilkat River tag codes have been recovered from other drainages. One coho salmon smolt with a 2001 Chilkat River tag code was sampled as it emigrated from Jordan Creek near Juneau in 2002 (Ericksen 2003). Two smolt were recaptured in the Berners River in 2000 with 1999 codes (Ericksen 2001). Although interesting, these irregular events are considered negligible and assumption (b) remains robust.

Because different capture gear was used during the first and second sampling events, it is unlikely that juvenile marking affected the ability to capture adults (assumption c). Other studies have shown that marked coho smolt do not suffer significantly higher mortality than unmarked fish (Elliott and Sterritt 1990; Vincent-Lang 1993). Because all fish had secondary marks (adipose fin clips) that were not lost, assumption (d) was satisfied. Overall, 98.3% of fish captured in the Chilkat River fish wheels were examined (1,996 examined out of 2,031 captured) for missing adipose fins; fish that were not examined either escaped or were overlooked. Once examined, fish were marked to prevent re-sampling, satisfying assumption (e).

In previous years there has been a disparity between smolt and adult ages. For coho salmon tagged in 2008, there was only a slight difference in ages; freshwater age-2. fish represented approximately 13.4% of the smolt emigration and 16.5% of the adult escapement. One possible explanation for this difference is that age-2. smolt had better marine survival than age-1. fish, which is validated in higher CWT recovery rates. A second explanation is that the minnow traps were biased toward smaller fish because the limited diameter of the G-40 minnow trap entrance tunnel excluded the largest coho salmon smolt. This phenomenon was investigated on the Unuk River in response to differential marking and survival rates between large and small smolt (Weller et al. 2005). That study concluded that minnow trap design could result in smolt estimates that were biased low by as much as 20%. A third explanation is that coho salmon smolt emigrating from Chilkat Lake were under-represented in event 1. Results from smolt sampling by CF at Chilkat Lake indicated that age-2. fish represented 27% of the population in 2006 (Elliott 2010), and 42% in 2008. These age-2. proportions are significantly higher than those of coho salmon smolt captured in the Chilkat River (Tables 4 and 6). In future years of the Chilkat River coho salmon smolt study, small (<85 mm) and medium/large (≥85mm) fish will continue to be marked with distinct tag codes to investigate marking or survival rate differences by size class.

Because it is sometimes difficult to identify the sex of ocean-phase fish by visual observation, the sex ratio of samples at the fish wheels may be inaccurate. Ericksen (2006) examined 62 coho salmon that were sampled at the fish wheels then recaptured and sexed on the spawning grounds. Assuming that sex determination is more reliable on the spawning grounds than in the lower river, 8 of 62 fish were incorrectly identified as females, and 6 out of 62 were incorrectly identified as males at the fish wheels. In mark-recapture years, sex compositions determined in the second sampling event can be used to accurately estimate proportions at age of males and females.

The 2009 total escapement estimate of coho salmon (including jacks) to the Chilkat River (48,867, SE = 9,402) was below average and most likely was the result of the lowest smolt emigration (716,689, SE= 88,013) since the Chilkat River CWT project began in 1999. Abundance of the 2009 return benefitted from an above average marine survival estimate (11.3%, SE = 1.9%), and below average marine exploitation (37.8%, SE = 4.7%). The above average marine survival rate, coupled with below average exploitation (Table 12), compensated for low smolt emigration abundance and the escapement goal (Ericksen and Fleischman 2006) was reached in 2009.

Despite high catch variability, the median date of coho salmon immigration at the Chilkat River fish wheels in 2009 (September 20) was consistent with the 1997–2008 average (September 19, Figure 6). The median date may not represent the distribution of catches, however. During a strong pulse of migrating coho salmon, 46% of the 2009 fish wheel catch occurred in a 10-day period from September 19 through 28, when 938 coho salmon were captured out of a season total of 2,031 fish (Figure 3). Consistent with prior years, this large migratory pulse could have been triggered by a precipitation event; the Chilkat River water level rose 39% over September 17–18, the two days directly preceding maximum fish wheel catches. Overall, the total fish wheel catch of coho salmon in 2009 was 22% lower than the1997–2008 average of 2,588 coho salmon, and was commensurate with the escapement estimate. Before 1997, operation of the Chilkat River fish wheels ended around September 15, which makes comparisons difficult.

Table 12.–Estimates of Chilkat River coho salmon smolt and adult production, 2000–2009.

| Return year, t | Number CWT smolt (t-l) | Smolt theta ($\theta_s$) | Smolt estimate | SE | Marine theta ($\theta_m$) | Marine harvest | SE | Inriver harvest | SE | Age-x.1 esc | SE | Total return | SE | Marine expl | SE | Marine survival | SE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000[a] | 25,915 | 0.019 | 1,237,056 | 219,715 | 0.019 | 39,546 | 3,745 | 853 | 221 | 84,843 | 16,330 | 125,242 | 16,755 | 0.316 | 0.046 | 0.101 | 0.023 |
| 2001[b] | 25,016 | 0.021 | 1,185,804 | 164,121 | 0.020 | 45,658 | 7,194 | 2,176 | 451 | 107,697 | 20,720 | 155,531 | 21,938 | 0.294 | 0.051 | 0.131 | 0.026 |
| 2002[c] | 36,114 | 0.012 | 2,970,458 | 377,695 | 0.012 | 110,105 | 10,355 | 3,888 | 742 | 204,787 | 31,071 | 318,780 | 32,759 | 0.345 | 0.040 | 0.107 | 0.018 |
| 2003[d] | 25,296 | 0.015 | 1,696,212 | 190,330 | 0.015 | 83,302 | 6,956 | 2,932 | 497 | 133,109 | 14,926 | 219,291 | 16,474 | 0.380 | 0.032 | 0.129 | 0.017 |
| 2004[e] | 24,563 | 0.012 | 1,938,322 | 401,419 | 0.010 | 128,466 | 19,882 | 3,169 | 661 | 67,053 | 12,901 | 198,688 | 23,710 | 0.647 | 0.054 | 0.103 | 0.025 |
| 2005[f] | 17,276 | 0.021 | 776,934 | 147,738 | 0.020 | 29,518 | 3,483 | 1,453 | 293 | 34,575 | 4,561 | 65,546 | 5,746 | 0.450 | 0.042 | 0.084 | 0.018 |
| 2006[g] | 26,342 | 0.014 | 1,807,837 | 217,352 | 0.013 | 70,813 | 7,632 | 2,082 | 293 | 79,050 | 15,210 | 151,945 | 17,020 | 0.466 | 0.053 | 0.084 | 0.014 |
| 2007[h] | 22,149 | 0.025 | 875,478 | 134,864 | 0.023 | 12,142 | 1,585 | 635 | 149 | 24,770 | 4,769 | 37,547 | 5,027 | 0.323 | 0.050 | 0.043 | 0.009 |
| 2008[i] | 24,104 | 0.027 | 893,032 | 95,380 | 0.025 | 52,989 | 3,518 | 991 | 261 | 56,369 | 10,846 | 110,349 | 11,405 | 0.480 | 0.050 | 0.124 | 0.018 |
| 2009 | 23,059 | 0.032 | 716,689 | 88,013 | 0.031 | 30,558 | 2,585 | 2,424 | 421 | 47,911 | 9,219 | 80,893 | 9,584 | 0.378 | 0.047 | 0.113 | 0.019 |
| Average 00-08 | 25,197 | 0.018 | 1,486,793 | 238,416 | 0.017 | 63,615 | 8,831 | 2,020 | 441 | 88,028 | 16,476 | 153,658 | 18,699 | 0.411 | 0.047 | 0.098 | 0.019 |

[a] From Ericksen (2001b).
[b] From Ericksen (2002b).
[c] From Ericksen (2003).
[d] From Ericksen and Chapell (2005).
[e] From Ericksen and Chapell (2006).
[f] From Ericksen (2006).
[g] From Elliott (2009).
[h] From Elliott (2010).
[i] From Elliott (2012).

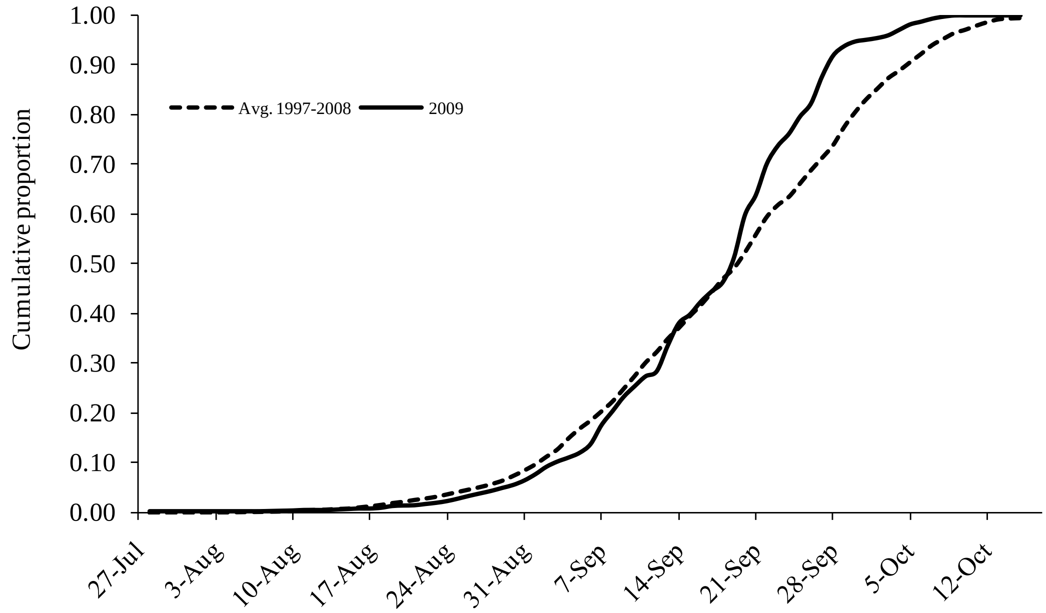


Figure 6.–Cumulative proportion of adult coho salmon captured in Chilkat River fish wheels during 2009 compared to the mean cumulative proportion of 1997–2008.

Because the number of stocks present decreases with proximity to natal streams, the percentage of Chilkat River coho salmon in the fishery harvest increased with proximity to the Chilkat River. The estimated harvest of Chilkat River fish was substantial in the Northwest Quadrant troll fishery (14,853, SE = 2,141), but those fish represented only 1.9% of the total harvest in that fishery (Table 10). The largest harvest occurred in the Lynn Canal drift gillnet fishery (15,179, SE = 1,437) where Chilkat River fish represented 46.3% of the total harvest.

The CWT recovery rate also increased with proximity to the Chilkat River. Despite a higher recovery rate from District 115 gillnet fisheries, however, there was no difference in the relative frequency of recoveries between the gillnet fishery and the Northwest Quadrant troll fishery. This indicates that tagged fish mixed well in the ocean environment. The combined gillnet (61.0%), troll (37.8%), seine (0.9%) and sport (0.3%) fisheries comprised 100% of all Chilkat River coho salmon CWT recoveries.

The 2009 harvest estimate of Chilkat River coho salmon represents minimum total harvest because not all fisheries were sampled, and some were not sampled at rates sufficient to detect small harvests. Some marine sport fishery sites (including Pelican, Prince William Sound, and Cook Inlet) were not sampled for CWTs, so stock contribution to these fisheries cannot be estimated. Furthermore, harvest contributions of Chilkat River coho salmon cannot be determined from tags recovered in mixed district fisheries, as expansions of harvest for Chilkat coho salmon are based on harvests for a particular district (Table 9).

The 2008 estimate of emigrating coho salmon smolt was only 48% of the 1999–2007 average and continued the trend of low smolt estimates since outmigration year 2006, but the estimated marine survival (11.3%, SE = 1.9%) continued the rebound from a low point in 2007 (4.3%, SE = 0.9%, Table 12) and is largely responsible for the escapement goal (Ericksen and Fleischman 2006) being met in 2009. Declining freshwater production in the Chilkat River drainage can be best demonstrated by examining the decaying relationship between spring coded wire trapping productivity as expressed by CPUE (tagged coho salmon per trap deployed) and resulting smolt population estimates.

For outmigration years 1999–2005, CPUE was a very useful predictor of smolt emigration estimates, as evidenced by an $R^2$ value of 0.98 when performing linear regression between the two data sets. Outmigration years 2006–2008 have sharply increased the error of this model, contributing 58% of the residual sum of squares error when fitting a regression line for all outmigration years (Figure 7). In outmigration years 2006–2008, the spring CPUE model predicts an average smolt emigration of 1,361,462 fish, when actual estimates average 828,400 (61% of predicted emigration). This contrasts sharply with previous years of the Chilkat River CWT project. In outmigration years 1999–2005, the CPUE model predicts an average smolt emigration of 1,492,253, compared to the actual estimate average of 1,656,207, only 11% higher. Methods during the spring CWT project have remained consistent and environmental conditions have also been relatively similar year to year. Causes for this decline in freshwater production should be investigated if this trend continues.

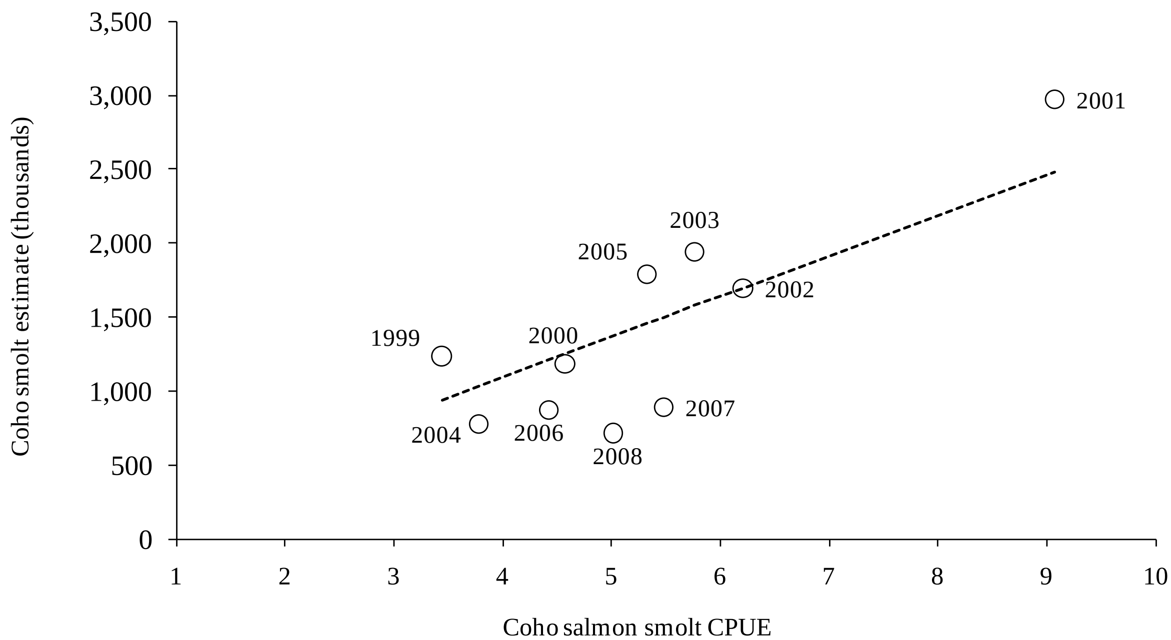


Figure 7.–Chilkat River coho salmon smolt spring coded wire tag minnow trapping CPUE and smolt emigration estimate for years 1999–2008.

The reduced ability of spring minnow trapping CPUE to predict smolt emigration size also hinders ability to predict the subsequent year's return; total return of Chilkat River coho salmon is largely dependent on the abundance of the previous year's smolt emigration. In 2002, for example, when marine survival was average (10.7%), the estimated return of 318,798 coho salmon was 118% higher than the 2000–2008 average (Table 12) due to the large smolt emigration (2,970,458 fish) in 2001. In contrast, marine survival was estimated at an above-average 12.4% for return year 2008, but the smolt outmigration in 2007 was below average at

893,032, resulting in a below average total return estimate of 110,349 (Figure 8, Table 12). Linear regression of smolt emigration on total return yields an $R^2$ value of 0.97 (Figure 9). The abundance of the previous year's smolt emigration estimate, therefore, is important indicator for predicting the return of Chilkat River coho salmon.

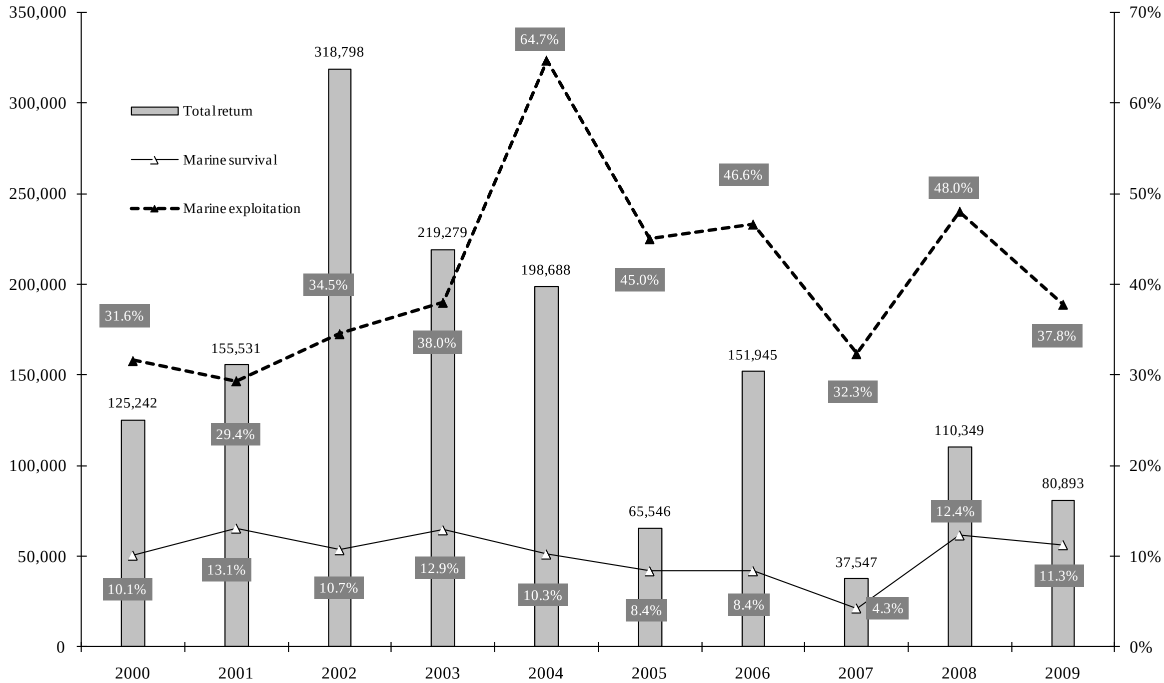


Figure 8.–Estimated total return, marine survival, and marine exploitation rate of Chilkat River coho salmon, 2000–2009.

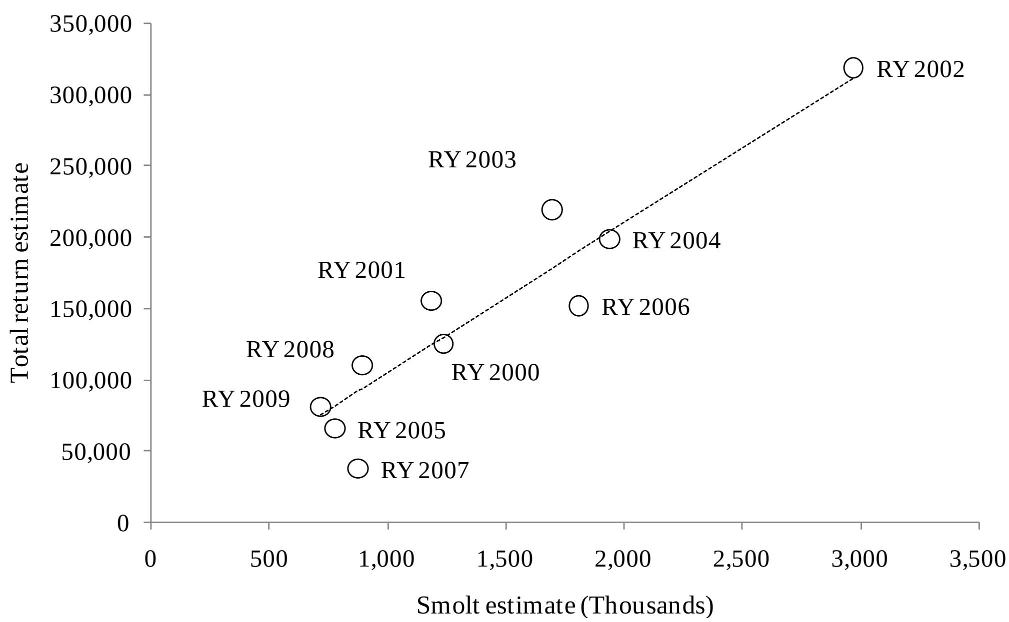


Figure 9.–Estimated smolt emigration and resulting total return of Chilkat River coho salmon, 2000–2009. Linear regression results in an R2 value of 0.97 and a significant slope with a P value of <0.001. RY = return year.

Production of Chilkat River coho salmon smolt is limited by the amount of rearing habitat (Ericksen and Fleischman 2006), which would indicate some degree of density dependence; however there is a weak relationship between smolt estimates and average fish size (Table 13, 55% negatively correlated). Average fish size is also not related to marine survival. Thomas Fulton, among others in the early 20th century, developed a method to measure the robustness of fish populations, called the K factor (K = (weight/length$^3$) x $10^5$), as an indicator of fish condition (Fulton 1902; Ricker 1975). The smolt abundance estimate, average K factor, and resulting marine survival were examined for Chilkat coho salmon (Table 13, Figure 10). The insignificant slope (P = 0.40) and poor fit ($R^2$ = 0.09) of the regression line show that overall smolt size has little effect on marine survival.

Table 13.–Smolt estimate, average smolt sizes, K factor (measure of robustness), and marine survival for Chilkat River coho salmon, 1999–2008.

| | Smolt | Age 1. | | | Age 2. | | | All ages | Marine |
|---|---|---|---|---|---|---|---|---|---|
| Smolt year | estimate | *n* | length | weight | *n* | length | weight | K factor | survival |
| 1999 | 1,237,056 | 236 | 80.0 | 5.4 | 46 | 101.0 | 10.3 | 1.046 | 10.1% |
| 2000 | 1,185,804 | 184 | 86.3 | 6.5 | 22 | 102.0 | 10.4 | 1.008 | 13.1% |
| 2001 | 2,970,458 | 379 | 85.0 | 6.4 | 58 | 101.0 | 7.1 | 0.995 | 10.7% |
| 2002 | 1,696,212 | 266 | 83.0 | 6.0 | 61 | 96.0 | 8.8 | 1.039 | 12.9% |
| 2003 | 1,938,322 | 315 | 85.0 | 6.2 | 22 | 104.0 | 10.9 | 1.007 | 10.3% |
| 2004 | 776,934 | 203 | 83.5 | 6.1 | 15 | 102.1 | 10.9 | 1.046 | 8.4% |
| 2005 | 1,807,837 | 398 | 83.0 | 5.9 | 38 | 105.0 | 11.2 | 1.026 | 8.4% |
| 2006 | 875,478 | 345 | 84.0 | 5.9 | 26 | 106.6 | 11.1 | 0.999 | 4.3% |
| 2007 | 893,032 | 352 | 85.4 | 6.4 | 54 | 105.3 | 11.5 | 1.038 | 12.4% |
| 2008 | 716,689 | 337 | 85.4 | 6.4 | 52 | 105.9 | 11.7 | 1.044 | 11.3% |

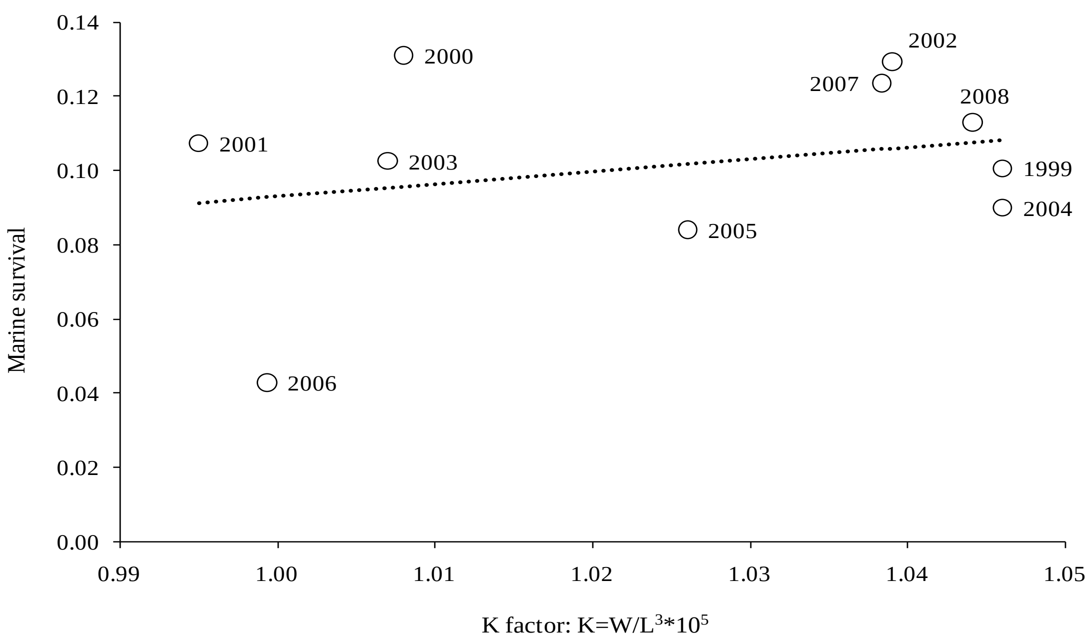


Figure 10.–Estimated smolt sizes as expressed by the K factor and resulting marine survival for Chilkat River coho salmon, smolt years 1999–2008. The data are 30% correlated and regression results in a poor fit with an $R^2$ value of 0.09.

Similarly, the relationship between smolt abundance and marine survival does not appear to be strong for Chilkat River coho salmon (Figure 11). Regression of survival on smolt abundance produces a line with an insignificant slope (P = 0.70) and the data are only 14% correlated. When examining the marine survival to smolt abundance relationship among all Southeast Alaska coho salmon indicator stocks, including Auke Creek, Berners River, Chilkat River, Taku River, Ford Arm Lake, Hugh Smith Lake, Chuck Creek, and Nakwasina River, the data are 14% correlated (Shaul et al. 2008). This weak relationship for the Chilkat River stock and other Southeast Alaska stocks could indicate that marine survival is more driven by ocean rearing conditions than freshwater abundance of rearing juvenile fish.

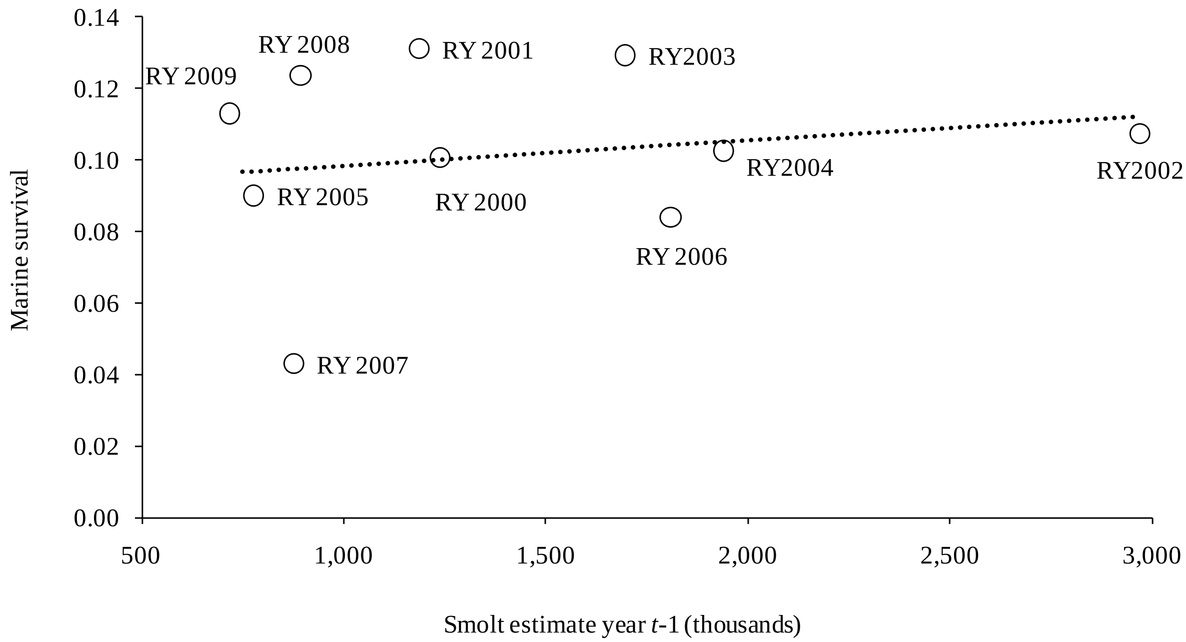


Figure 11.–Observed smolt outmigration estimates and observed and predicted marine survival for Chilkat River coho salmon, return years 2000–2009. Linear regression results in an $R^2$ value of 0.02; predicted marine survival has an insignificant slope with P value of 0.70, and the data are 14% correlated. RY = return year.

A predictor of marine survival that may be useful for making inseason fishery management decisions, such as the Chilkat River sport bag limits for coho salmon, is the CWT recovery rate from commercial troll fisheries (Table 14, Figure 12). Examining recovery rates from 2000 to 2009 for Chilkat River coho salmon reveals that marine recovery and marine survival are 99% positively correlated. Because troll fishery CWT interceptions largely occur before the escapement of Chilkat River coho salmon, and the recovery rate is based on known quantities (smolt released with tags and CWTs recovered), assessing this relationship can help predict marine survival and, after adding the inseason marking fraction $\theta_m$, can be a useful predictor of return strength (Figure 13).

Table 14.–Chilkat River coho salmon marine coded wire tags released and recovered 2000–2009.

| Return year | Smolt tagged ($y$ - 1) | Marine theta | Marine coded wire tags | Marine recovery rate | Adult return |
|---|---|---|---|---|---|
| 2000 | 25,915 | 0.019 | 265 | 1.02% | 125,242 |
| 2001 | 25,016 | 0.020 | 251 | 1.00% | 155,531 |
| 2002 | 36,114 | 0.012 | 329 | 0.91% | 318,798 |
| 2003 | 25,296 | 0.015 | 424 | 1.68% | 219,279 |
| 2004 | 24,563 | 0.010 | 254 | 1.03% | 198,688 |
| 2005 | 17,276 | 0.020 | 142 | 0.82% | 65,546 |
| 2006 | 26,342 | 0.013 | 217 | 0.82% | 151,945 |
| 2007 | 22,149 | 0.023 | 78 | 0.35% | 37,547 |
| 2008 | 24,104 | 0.025 | 370 | 1.54% | 110,349 |
| 2009 | 23,059 | 0.031 | 325 | 1.41% | 80,893 |
| average | 24,983 | 0.019 | 266 | 1.06% | 146,365 |

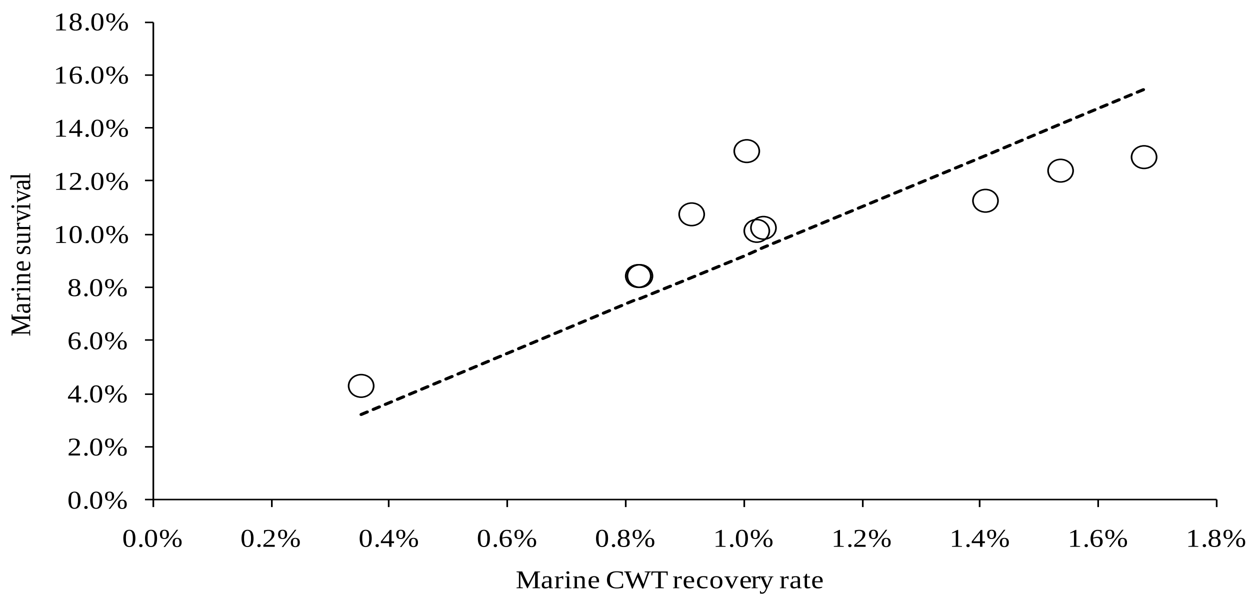


Figure 12.–Marine coded wire tag (CWT) recovery rate and marine survival for Chilkat River coho salmon, 2000–2009. The data are 99% correlated and linear regression results in an $R^2$ value of 0.97.

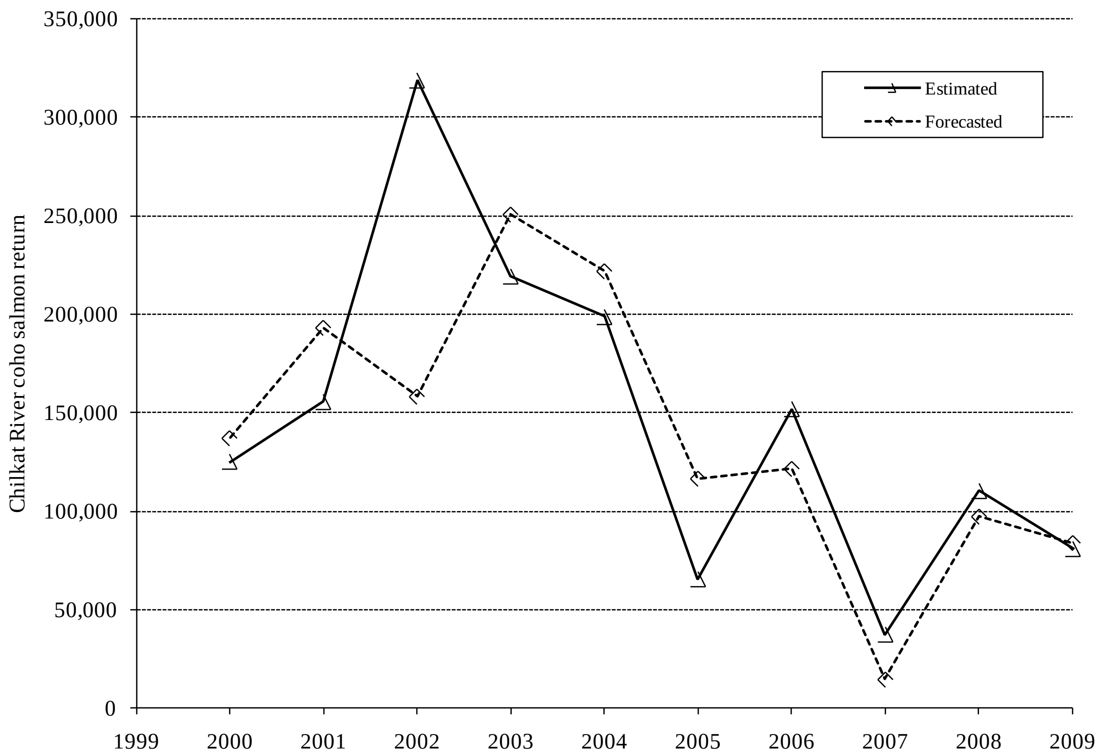


Figure 13.–Inseason forecasted returns and postseason estimated returns of Chilkat River coho salmon, 2001–2009. The number of coded wire tags released in year $t$ - 1, average marine theta, and the marine coded wire tag recovery rate are used to generate the forecasted total. Return year 2002 accounts for 77% of total forecast error for years 2000–2009.

The forecasting model estimates 2 parameters; one for the CWT recovery rate from the troll fishery represented by ρ, and the other is for the marine theta, represented by ϕ. Non-linear regression using the least squares method produces estimates for ρ and ϕ, including the residual term ε representing additive error from the model:

$$\text{Estimated return} = \rho(\text{troll CWT \%}) - \phi(\theta_m) + \varepsilon$$

Most troll fishery interceptions occur by the end of statistical week 38, which coincides with mid September. That time frame is also the median date of the Chilkat River fish wheel catch, when marine theta can be reasonably estimated. Using the total CWTs released in year $t$-1, marine theta, and the marine CWT recovery rate produces inseason forecasted return totals with a forecasting error of less than 25% in 7 of the 10 years examined. Return year 2002 was one anomaly, as the return was the highest recorded and exceeded expectations, and accounts for 77% of the model error, expressed as a proportion of residual sum of squares (Table 12, Figure 13). The model has accurately predicted return in 2008 and 2009, as forecasting error has been 9% and 8%, respectively. Prior forecasts of coho salmon return have used CWTs released with average marine survival and average marine exploitation rates; using inseason marine CWT recovery rates allows for more accurate forecasting while utilizing contemporary data. As more data are collected in subsequent years, this forecasting tool will be developed further and should continue to be studied, to predict overall return and escapement of coho salmon to the Chilkat River.

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Larry Derby, Jane Pascoe, Aaron Thomas, Scott Ramsey, Fred LoFaso, and Dana Van Burgh III worked in the field to capture, mark, and sample smolt during the spring 2008. Rob Pettett, Fred LoFaso, and Tim Brush worked to capture and sample smolt at the Chilkat Lake weir during spring 2008. Mark Eisenman, Dave Folletti, Ted Hart, Don Hotch, and Mike Fick captured and sampled adult coho salmon at the fish wheels during fall 2009. Chilkoot Fish & Caviar in Haines, Alaska, provided salmon eggs, which were used for minnow-trap bait to capture juvenile coho salmon. The State of Alaska Parks Division, who manages the Chilkat Bald Eagle Preserve, allowed us to use the Chilkat River tagging site in 2008. Sue Millard, SF in Douglas, processed and aged scales from sampled coho salmon. Employees at the CF Mark, Tag, and Age Laboratory in Juneau dissected heads from adipose-finclipped coho salmon to remove and read CWTs. Sarah Power with SF Region 1 provided biometric support in the study design and analysis. Sarah Power and John Der Hovanisian provided critical review of this report. Stacey Poulson prepared the final layout of this report for publication.


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# APPENDIX A

Appendix A1.–Random and select recoveries of coded wire tagged Chilkat River coho salmon in 2009.

| Head number | Tag code | Gear | Port | Recovery date | Statistical week | Quad-rant | District | Sub-district | Length |
|---|---|---|---|---|---|---|---|---|---|
| RANDOM RECOVERIES | | | | | | | | | |
| 080340 | 041507 | Sport | Elfin Cove | 8/30/2009 | 36 | NW | 113 | 21 | 630 |
| 343201 | 041374 | Sport | Haines | 10/4/2009 | 41 | NE | 115 | 32 | 720 |
| 343202 | 041373 | Sport | Haines | 10/5/2009 | 41 | NE | 115 | 32 | 765 |
| 343066 | 041373 | Sport | Haines | 10/10/2009 | 41 | NE | 115 | 32 | 605 |
| 343203 | 041374 | Sport | Haines | 10/11/2009 | 42 | NE | 115 | 32 | 665 |
| 343204 | 041374 | Sport | Haines | 10/12/2009 | 42 | NE | 115 | 32 | 680 |
| 343205 | 041373 | Sport | Haines | 10/24/2009 | 43 | NE | 115 | 32 | 585 |
| 343206 | 041373 | Sport | Haines | 10/28/2009 | 44 | NE | 115 | 32 | ND |
| 076959 | 041373 | Drift gillnet | Excursion Inlet | 8/18/2009 | 34 | NE | 115 | ND | 540 |
| 531040 | 041373 | Drift gillnet | Excursion Inlet | 8/26/2009 | 35 | NE | 115 | ND | 605 |
| 531035 | 041374 | Drift gillnet | Excursion Inlet | 8/26/2009 | 35 | NE | 115 | ND | 600 |
| 531038 | 041374 | Drift gillnet | Excursion Inlet | 8/26/2009 | 35 | NE | 115 | ND | 605 |
| 531039 | 041374 | Drift gillnet | Excursion Inlet | 8/26/2009 | 35 | NE | 115 | ND | 640 |
| 531037 | 041374 | Drift gillnet | Excursion Inlet | 8/26/2009 | 35 | NE | 115 | ND | 695 |
| 531202 | 041373 | Drift gillnet | Excursion Inlet | 9/1/2009 | 36 | NE | 115 | ND | 510 |
| 531203 | 041373 | Drift gillnet | Excursion Inlet | 9/1/2009 | 36 | NE | 115 | ND | 550 |
| 531204 | 041373 | Drift gillnet | Excursion Inlet | 9/1/2009 | 36 | NE | 115 | ND | 565 |
| 531200 | 041373 | Drift gillnet | Excursion Inlet | 9/1/2009 | 36 | NE | 115 | ND | 585 |
| 531208 | 041373 | Drift gillnet | Excursion Inlet | 9/1/2009 | 36 | NE | 115 | ND | 585 |
| 531198 | 041373 | Drift gillnet | Excursion Inlet | 9/1/2009 | 36 | NE | 115 | ND | 655 |
| 531209 | 041373 | Drift gillnet | Excursion Inlet | 9/1/2009 | 36 | NE | 115 | ND | 690 |
| 531205 | 041374 | Drift gillnet | Excursion Inlet | 9/1/2009 | 36 | NE | 115 | ND | 460 |
| 531195 | 041374 | Drift gillnet | Excursion Inlet | 9/1/2009 | 36 | NE | 115 | ND | 500 |
| 531206 | 041374 | Drift gillnet | Excursion Inlet | 9/1/2009 | 36 | NE | 115 | ND | 500 |
| 531201 | 041374 | Drift gillnet | Excursion Inlet | 9/1/2009 | 36 | NE | 115 | ND | 505 |
| 531197 | 041374 | Drift gillnet | Excursion Inlet | 9/1/2009 | 36 | NE | 115 | ND | 620 |
| 531207 | 041374 | Drift gillnet | Excursion Inlet | 9/1/2009 | 36 | NE | 115 | ND | 660 |
| 531199 | 041374 | Drift gillnet | Excursion Inlet | 9/1/2009 | 36 | NE | 115 | ND | 680 |
| 531217 | 041370 | Drift gillnet | Excursion Inlet | 9/2/2009 | 36 | NE | 115 | ND | 680 |
| 531220 | 041373 | Drift gillnet | Excursion Inlet | 9/2/2009 | 36 | NE | 115 | ND | 580 |
| 531214 | 041374 | Drift gillnet | Excursion Inlet | 9/2/2009 | 36 | NE | 115 | ND | 560 |
| 531216 | 041374 | Drift gillnet | Excursion Inlet | 9/2/2009 | 36 | NE | 115 | ND | 645 |
| 531213 | 041374 | Drift gillnet | Excursion Inlet | 9/2/2009 | 36 | NE | 115 | ND | 670 |
| 531215 | 041374 | Drift gillnet | Excursion Inlet | 9/2/2009 | 36 | NE | 115 | ND | 695 |
| 540260 | 041373 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 510 |
| 540255 | 041373 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 520 |
| 540276 | 041373 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 520 |
| 540273 | 041373 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 530 |
| 540347 | 041373 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 545 |
| 540257 | 041373 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 590 |
| 540349 | 041373 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 600 |

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| Head number | Tag code | Gear | Port | Recovery date | Statistical week | Quad-rant | District | Sub-district | Length |
|---|---|---|---|---|---|---|---|---|---|
| 540266 | 041373 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 600 |
| 540262 | 041373 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 640 |
| 540279 | 041373 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 690 |
| 540265 | 041374 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 480 |
| 540271 | 041374 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 510 |
| 540278 | 041374 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 510 |
| 540274 | 041374 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 520 |
| 540348 | 041374 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 525 |
| 540264 | 041374 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 530 |
| 540251 | 041374 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 550 |
| 540270 | 041374 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 550 |
| 540272 | 041374 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 550 |
| 540281 | 041374 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 570 |
| 540256 | 041374 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 580 |
| 540263 | 041374 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 600 |
| 540253 | 041374 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 620 |
| 540258 | 041374 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 620 |
| 540344 | 041374 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 630 |
| 540275 | 041374 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 640 |
| 540339 | 041374 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 660 |
| 540267 | 041374 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 660 |
| 540269 | 041374 | Drift gillnet | Juneau | 9/8/2009 | 37 | NE | 115 | ND | 710 |
| 540293 | 041373 | Drift gillnet | Juneau | 9/9/2009 | 37 | NE | 115 | ND | 450 |
| 540283 | 041373 | Drift Gillnet | Juneau | 9/9/2009 | 37 | NE | 115 | ND | 580 |
| 540294 | 041373 | Drift gillnet | Juneau | 9/9/2009 | 37 | NE | 115 | ND | 625 |
| 540292 | 041373 | Drift gillnet | Juneau | 9/9/2009 | 37 | NE | 115 | ND | 655 |
| 540282 | 041374 | Drift gillnet | Juneau | 9/9/2009 | 37 | NE | 115 | ND | 470 |
| 540290 | 041374 | Drift gillnet | Juneau | 9/9/2009 | 37 | NE | 115 | ND | 535 |
| 540288 | 041374 | Drift gillnet | Juneau | 9/9/2009 | 37 | NE | 115 | ND | 580 |
| 540297 | 041374 | Drift gillnet | Juneau | 9/9/2009 | 37 | NE | 115 | ND | 600 |
| 540286 | 041374 | Drift gillnet | Juneau | 9/9/2009 | 37 | NE | 115 | ND | 615 |
| 540295 | 041374 | Drift gillnet | Juneau | 9/9/2009 | 37 | NE | 115 | ND | 675 |
| 059447 | 041370 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 700 |
| 059464 | 041373 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 460 |
| 059450 | 041373 | Drift Gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 520 |
| 059442 | 041373 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 560 |
| 059453 | 041373 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 560 |
| 059438 | 041373 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 580 |
| 059437 | 041373 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 590 |
| 059431 | 041373 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 600 |
| 059472 | 041373 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 600 |
| 059440 | 041373 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 610 |

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| Head number | Tag code | Gear | Port | Recovery date | Statistical week | Quad-rant | district | Sub-district | Length |
|---|---|---|---|---|---|---|---|---|---|
| 059452 | 041373 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 620 |
| 059449 | 041373 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 630 |
| 059458 | 041373 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 670 |
| 059430 | 041374 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 490 |
| 059435 | 041374 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 500 |
| 059443 | 041374 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 530 |
| 059451 | 041374 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 530 |
| 059448 | 041374 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 540 |
| 059445 | 041374 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 560 |
| 059454 | 041374 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 560 |
| 059428 | 041374 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 570 |
| 059433 | 041374 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 590 |
| 059432 | 041374 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 600 |
| 059444 | 041374 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 610 |
| 059446 | 041374 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 610 |
| 059467 | 041374 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 610 |
| 059436 | 041374 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 650 |
| 059456 | 041374 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 660 |
| 059439 | 041374 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 680 |
| 059457 | 041374 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 680 |
| 059474 | 041374 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 690 |
| 059434 | 041374 | Drift gillnet | Juneau | 9/16/2009 | 38 | NE | 115 | ND | 700 |
| 059483 | 041373 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 640 |
| 059476 | 041373 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 690 |
| 059480 | 041374 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 575 |
| 059481 | 041374 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 585 |
| 059536 | 041374 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 585 |
| 059485 | 041374 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 590 |
| 059523 | 041374 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 600 |
| 059532 | 041374 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 615 |
| 059527 | 041374 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 640 |
| 059477 | 041374 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 645 |
| 059478 | 041374 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 655 |
| 059541 | 041374 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 660 |
| 059491 | 041374 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 665 |
| 059548 | 041374 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 665 |
| 059545 | 041374 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 670 |
| 059547 | 041374 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 675 |
| 059530 | 041374 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 685 |
| 059533 | 041374 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 685 |
| 059538 | 041374 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 705 |
| 059549 | 041374 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 720 |

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Appendix A1.–Page 4 of 10.

| Head number | Tag code | Gear | Port | Recovery date | Statistical week | Quad-rant | District | Sub-district | Length |
|---|---|---|---|---|---|---|---|---|---|
| 059500 | 041507 | Drift gillnet | Juneau | 9/22/2009 | 39 | NE | 115 | ND | 605 |
| 059582 | 041373 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 530 |
| 059565 | 041373 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 535 |
| 059575 | 041373 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 555 |
| 059568 | 041373 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 565 |
| 059573 | 041373 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 585 |
| 059564 | 041373 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 605 |
| 059571 | 041373 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 610 |
| 059574 | 041373 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 625 |
| 059561 | 041373 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 630 |
| 059566 | 041373 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 700 |
| 059567 | 041373 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 710 |
| 059559 | 041374 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 550 |
| 059584 | 041374 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 570 |
| 059596 | 041374 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 575 |
| 059579 | 041374 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 580 |
| 059585 | 041374 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 590 |
| 059576 | 041374 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 605 |
| 059592 | 041374 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 625 |
| 059598 | 041374 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 645 |
| 059558 | 041374 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 660 |
| 059581 | 041374 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 660 |
| 059577 | 041374 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 665 |
| 059590 | 041374 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 670 |
| 059599 | 041374 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 675 |
| 059588 | 041374 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 680 |
| 059597 | 041374 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 680 |
| 059595 | 041374 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 690 |
| 059589 | 041374 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 715 |
| 059600 | 041507 | Drift gillnet | Juneau | 9/24/2009 | 39 | NE | 115 | ND | 530 |
| 059669 | 041373 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 570 |
| 059609 | 041373 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 580 |
| 059652 | 041373 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 580 |
| 059677 | 041373 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 595 |
| 059659 | 041373 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 600 |
| 059671 | 041373 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 600 |
| 059664 | 041373 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 605 |
| 059616 | 041373 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 615 |
| 059636 | 041373 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 615 |
| 059673 | 041373 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 615 |
| 059654 | 041373 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 620 |
| 059678 | 041373 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 625 |

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| Head number | Tag code | Gear | Port | Recovery date | Statistical week | Quad-rant | District | Sub-district | Length |
|---|---|---|---|---|---|---|---|---|---|
| 059672 | 041373 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 640 |
| 059653 | 041373 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 650 |
| 059646 | 041374 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 550 |
| 059676 | 041374 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 570 |
| 059650 | 041374 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 585 |
| 059681 | 041374 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 610 |
| 059643 | 041374 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 615 |
| 059674 | 041374 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 625 |
| 059615 | 041374 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 630 |
| 059670 | 041374 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 630 |
| 059660 | 041374 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 635 |
| 059661 | 041374 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 635 |
| 059656 | 041374 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 640 |
| 059635 | 041374 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 660 |
| 059665 | 041374 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 665 |
| 059666 | 041374 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 665 |
| 059634 | 041374 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 670 |
| 059675 | 041374 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 685 |
| 059618 | 041374 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 690 |
| 059651 | 041374 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 690 |
| 059658 | 041374 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 705 |
| 059667 | 041374 | Drift gillnet | Juneau | 9/30/2009 | 40 | NE | 115 | ND | 775 |
| 059704 | 041373 | Drift gillnet | Juneau | 10/7/2009 | 41 | NE | 115 | ND | 580 |
| 059687 | 041373 | Drift gillnet | Juneau | 10/7/2009 | 41 | NE | 115 | ND | 605 |
| 059695 | 041373 | Drift gillnet | Juneau | 10/7/2009 | 41 | NE | 115 | ND | 605 |
| 059686 | 041373 | Drift gillnet | Juneau | 10/7/2009 | 41 | NE | 115 | ND | 610 |
| 059702 | 041373 | Drift gillnet | Juneau | 10/7/2009 | 41 | NE | 115 | ND | 610 |
| 059689 | 041373 | Drift gillnet | Juneau | 10/7/2009 | 41 | NE | 115 | ND | 640 |
| 059701 | 041373 | Drift gillnet | Juneau | 10/7/2009 | 41 | NE | 115 | ND | 655 |
| 059690 | 041373 | Drift gillnet | Juneau | 10/7/2009 | 41 | NE | 115 | ND | 695 |
| 059685 | 041374 | Drift gillnet | Juneau | 10/7/2009 | 41 | NE | 115 | ND | 575 |
| 059694 | 041374 | Drift gillnet | Juneau | 10/7/2009 | 41 | NE | 115 | ND | 585 |
| 059693 | 041374 | Drift gillnet | Juneau | 10/7/2009 | 41 | NE | 115 | ND | 595 |
| 059688 | 041374 | Drift gillnet | Juneau | 10/7/2009 | 41 | NE | 115 | ND | 610 |
| 059700 | 041374 | Drift gillnet | Juneau | 10/7/2009 | 41 | NE | 115 | ND | 610 |
| 059684 | 041374 | Drift gillnet | Juneau | 10/7/2009 | 41 | NE | 115 | ND | 640 |
| 059697 | 041374 | Drift gillnet | Juneau | 10/7/2009 | 41 | NE | 115 | ND | 640 |
| 059691 | 041374 | Drift gillnet | Juneau | 10/7/2009 | 41 | NE | 115 | ND | 650 |
| 059692 | 041374 | Drift gillnet | Juneau | 10/7/2009 | 41 | NE | 115 | ND | 650 |
| 059696 | 041374 | Drift gillnet | Juneau | 10/7/2009 | 41 | NE | 115 | ND | 675 |
| 059703 | 041374 | Drift gillnet | Juneau | 10/7/2009 | 41 | NE | 115 | ND | 685 |
| 076960 | 041373 | Purse seine | Excursion Inlet | 8/19/2009 | 34 | NE | 112 | 16 | 505 |

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| Head number | Tag code | Gear | Port | Recovery date | Statistical week | Quad-rant | District | Sub-district | Length |
|---|---|---|---|---|---|---|---|---|---|
| 076964 | 041374 | Purse seine | Excursion Inlet | 8/19/2009 | 34 | NE | 112 | 16 | 435 |
| 076961 | 041374 | Purse seine | Excursion Inlet | 8/19/2009 | 34 | NE | 112 | 16 | 510 |
| 345146 | 041373 | Troll | Hoonah | 7/19/2009 | 30 | NW | ND | ND | 460 |
| 345151 | 041374 | Troll | Hoonah | 7/19/2009 | 30 | NW | ND | ND | 613 |
| 339604 | 041370 | Troll | Sitka | 7/25/2009 | 30 | NW | 113 | ND | 650 |
| 079749 | 041374 | Troll | Excursion Inlet | 7/28/2009 | 31 | NW | ND | ND | 650 |
| 358188 | 041374 | Troll | Sitka | 8/3/2009 | 32 | NW | ND | ND | 550 |
| 345193 | 041374 | Troll | Hoonah | 8/4/2009 | 32 | NW | ND | ND | 651 |
| 076574 | 041373 | Troll | Excursion Inlet | 8/8/2009 | 32 | NW | ND | ND | 545 |
| 345239 | 041373 | Troll | Hoonah | 8/10/2009 | 33 | NW | ND | ND | 534 |
| 345205 | 041374 | Troll | Hoonah | 8/10/2009 | 33 | NW | ND | ND | 560 |
| 345241 | 041374 | Troll | Hoonah | 8/10/2009 | 33 | NW | ND | ND | 580 |
| 076618 | 041373 | Troll | Excursion Inlet | 8/11/2009 | 33 | NW | ND | ND | 540 |
| 076612 | 041373 | Troll | Excursion Inlet | 8/11/2009 | 33 | NW | ND | ND | 550 |
| 334941 | 041373 | Troll | Juneau | 8/11/2009 | 33 | NW | ND | ND | 670 |
| 076636 | 041374 | Troll | Excursion Inlet | 8/11/2009 | 33 | NW | ND | ND | 525 |
| 334936 | 041374 | Troll | Juneau | 8/11/2009 | 33 | NW | ND | ND | 590 |
| 345258 | 041373 | Troll | Hoonah | 8/12/2009 | 33 | NW | 116 | 11 | 536 |
| 085128 | 041373 | Troll | Yakutat | 8/12/2009 | 33 | NW | 116 | 12 | 535 |
| 345247 | 041373 | Troll | Hoonah | 8/12/2009 | 33 | NW | ND | ND | 498 |
| 334911 | 041374 | Troll | Juneau | 8/12/2009 | 33 | NW | 116 | ND | 643 |
| 345218 | 041374 | Troll | Hoonah | 8/12/2009 | 33 | NW | ND | ND | 613 |
| 076659 | 041373 | Troll | Excursion Inlet | 8/20/2009 | 34 | NW | ND | ND | 515 |
| 076662 | 041373 | Troll | Excursion Inlet | 8/20/2009 | 34 | NW | ND | ND | 570 |
| 076990 | 041374 | Troll | Excursion Inlet | 8/20/2009 | 34 | NW | ND | ND | 465 |
| 076666 | 041374 | Troll | Excursion Inlet | 8/20/2009 | 34 | NW | ND | ND | 630 |
| 076742 | 041374 | Troll | Excursion Inlet | 8/23/2009 | 35 | NW | ND | ND | 450 |
| 360537 | 041374 | Troll | Sitka | 8/23/2009 | 35 | NW | ND | ND | ND |
| 531086 | 041373 | Troll | Excursion Inlet | 8/26/2009 | 35 | NW | ND | ND | 500 |
| 531068 | 041374 | Troll | Excursion Inlet | 8/26/2009 | 35 | NW | ND | ND | 545 |
| 531050 | 041374 | Troll | Excursion Inlet | 8/26/2009 | 35 | NW | ND | ND | 605 |
| 359389 | 041374 | Troll | Sitka | 8/27/2009 | 35 | NW | 113 | ND | 670 |
| 531093 | 041374 | Troll | Excursion Inlet | 8/28/2009 | 35 | NW | 114 | 25 | 545 |
| 531157 | 041373 | Troll | Excursion Inlet | 8/29/2009 | 35 | NW | 114 | 21 | 505 |
| 531150 | 041373 | Troll | Excursion Inlet | 8/29/2009 | 35 | NW | 114 | 21 | 530 |
| 531163 | 041373 | Troll | Excursion Inlet | 8/29/2009 | 35 | NW | 114 | 21 | 550 |
| 531144 | 041373 | Troll | Excursion Inlet | 8/29/2009 | 35 | NW | 114 | 21 | 555 |
| 531152 | 041373 | Troll | Excursion Inlet | 8/29/2009 | 35 | NW | 114 | 21 | 560 |
| 531112 | 041373 | Troll | Excursion Inlet | 8/29/2009 | 35 | NW | 114 | 21 | 575 |
| 531110 | 041373 | Troll | Excursion Inlet | 8/29/2009 | 35 | NW | 114 | 21 | 600 |
| 531123 | 041374 | Troll | Excursion Inlet | 8/29/2009 | 35 | NW | 114 | 21 | 530 |
| 531134 | 041374 | Troll | Excursion Inlet | 8/29/2009 | 35 | NW | 114 | 21 | 540 |

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| Head number | Tag code | Gear | Port | Recovery date | Statistical week | Quad-rant | District | Sub-district | Length |
|---|---|---|---|---|---|---|---|---|---|
| 531108 | 041374 | Troll | Excursion Inlet | 8/29/2009 | 35 | NW | 114 | 21 | 585 |
| 531105 | 041374 | Troll | Excursion Inlet | 8/29/2009 | 35 | NW | 114 | 21 | 600 |
| 531140 | 041374 | Troll | Excursion Inlet | 8/29/2009 | 35 | NW | 114 | 21 | 600 |
| 531149 | 041374 | Troll | Excursion Inlet | 8/29/2009 | 35 | NW | 114 | 21 | 610 |
| 531121 | 041374 | Troll | Excursion Inlet | 8/29/2009 | 35 | NW | 114 | 21 | 615 |
| 531139 | 041374 | Troll | Excursion Inlet | 8/29/2009 | 35 | NW | 114 | 21 | 635 |
| 531159 | 041374 | Troll | Excursion Inlet | 8/29/2009 | 35 | NW | 114 | 21 | 655 |
| 531175 | 041373 | Troll | Excursion Inlet | 8/31/2009 | 36 | NW | ND | ND | 485 |
| 531190 | 041373 | Troll | Excursion Inlet | 8/31/2009 | 36 | NW | ND | ND | 555 |
| 531166 | 041373 | Troll | Excursion Inlet | 8/31/2009 | 36 | NW | ND | ND | 575 |
| 531188 | 041373 | Troll | Excursion Inlet | 8/31/2009 | 36 | NW | ND | ND | 595 |
| 531165 | 041374 | Troll | Excursion Inlet | 8/31/2009 | 36 | NW | ND | ND | 550 |
| 531186 | 041374 | Troll | Excursion Inlet | 8/31/2009 | 36 | NW | ND | ND | 570 |
| 531191 | 041374 | Troll | Excursion Inlet | 8/31/2009 | 36 | NW | ND | ND | 600 |
| 531180 | 041374 | Troll | Excursion Inlet | 8/31/2009 | 36 | NW | ND | ND | 615 |
| 531192 | 041374 | Troll | Excursion Inlet | 8/31/2009 | 36 | NW | ND | ND | 640 |
| 345619 | 041373 | Troll | Hoonah | 9/1/2009 | 36 | NW | ND | ND | 544 |
| 345647 | 041373 | Troll | Hoonah | 9/1/2009 | 36 | NW | ND | ND | 565 |
| 345634 | 041374 | Troll | Hoonah | 9/1/2009 | 36 | NW | ND | ND | 473 |
| 345605 | 041374 | Troll | Hoonah | 9/1/2009 | 36 | NW | ND | ND | 522 |
| 345640 | 041374 | Troll | Hoonah | 9/1/2009 | 36 | NW | ND | ND | 575 |
| 345606 | 041374 | Troll | Hoonah | 9/1/2009 | 36 | NW | ND | ND | 587 |
| 345613 | 041374 | Troll | Hoonah | 9/1/2009 | 36 | NW | ND | ND | 680 |
| 345610 | 041373 | Troll | Hoonah | 9/2/2009 | 36 | NW | 114 | 25 | 472 |
| 531255 | 041373 | Troll | Excursion Inlet | 9/2/2009 | 36 | NW | ND | ND | 645 |
| 531234 | 041374 | Troll | Excursion Inlet | 9/2/2009 | 36 | NW | ND | ND | 550 |
| 531243 | 041374 | Troll | Excursion Inlet | 9/2/2009 | 36 | NW | ND | ND | 580 |
| 085239 | 041373 | Troll | Yakutat | 9/3/2009 | 36 | NW | 189 | 30 | 510 |
| 339493 | 041374 | Troll | Sitka | 9/3/2009 | 36 | NW | 113 | 61 | 615 |
| 339530 | 041374 | Troll | Sitka | 9/3/2009 | 36 | NW | 113 | ND | 660 |
| 085238 | 041374 | Troll | Yakutat | 9/3/2009 | 36 | NW | 189 | 30 | 595 |
| 345678 | 041374 | Troll | Hoonah | 9/3/2009 | 36 | NW | ND | ND | 568 |
| 365732 | 041374 | Troll | Sitka | 9/5/2009 | 36 | NW | 113 | 45 | 710 |
| 359906 | 041374 | Troll | Sitka | 9/7/2009 | 37 | NW | 113 | ND | 580 |
| 359904 | 041374 | Troll | Sitka | 9/7/2009 | 37 | NW | 113 | ND | 675 |
| 365911 | 041373 | Troll | Sitka | 9/8/2009 | 37 | NW | 113 | ND | 525 |
| 365931 | 041373 | Troll | Sitka | 9/8/2009 | 37 | NW | 113 | ND | 580 |
| 365902 | 041373 | Troll | Sitka | 9/8/2009 | 37 | NW | 113 | ND | 600 |
| 345713 | 041374 | Troll | Hoonah | 9/8/2009 | 37 | NW | ND | ND | 614 |
| 345705 | 041374 | Troll | Hoonah | 9/8/2009 | 37 | NW | ND | ND | 640 |
| 345701 | 041374 | Troll | Hoonah | 9/8/2009 | 37 | NW | ND | ND | 682 |
| 345711 | 041373 | Troll | Hoonah | 9/9/2009 | 37 | NW | 114 | 50 | 645 |

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| Head number | Tag code | Gear | Port | Recovery date | Statistical week | Quad-rant | District | Sub-district | Length |
|---|---|---|---|---|---|---|---|---|---|
| 068814 | 041373 | Troll | Juneau | 9/9/2009 | 37 | NW | ND | ND | 514 |
| 068824 | 041373 | Troll | Juneau | 9/9/2009 | 37 | NW | ND | ND | 520 |
| 068828 | 041373 | Troll | Juneau | 9/9/2009 | 37 | NW | ND | ND | 540 |
| 068821 | 041373 | Troll | Juneau | 9/9/2009 | 37 | NW | ND | ND | 710 |
| 345695 | 041374 | Troll | Hoonah | 9/9/2009 | 37 | NW | 114 | 21 | 665 |
| 345685 | 041374 | Troll | Hoonah | 9/9/2009 | 37 | NW | 114 | 21 | 690 |
| 345688 | 041374 | Troll | Hoonah | 9/9/2009 | 37 | NW | 114 | 21 | 728 |
| 068851 | 041374 | Troll | Juneau | 9/9/2009 | 37 | NW | ND | ND | 450 |
| 068847 | 041374 | Troll | Juneau | 9/9/2009 | 37 | NW | ND | ND | 525 |
| 068890 | 041374 | Troll | Juneau | 9/9/2009 | 37 | NW | ND | ND | 560 |
| 068884 | 041374 | Troll | Juneau | 9/9/2009 | 37 | NW | ND | ND | 610 |
| 068873 | 041374 | Troll | Juneau | 9/9/2009 | 37 | NW | ND | ND | 630 |
| 068844 | 041374 | Troll | Juneau | 9/9/2009 | 37 | NW | ND | ND | 650 |
| 068822 | 041374 | Troll | Juneau | 9/9/2009 | 37 | NW | ND | ND | 670 |
| 068870 | 041374 | Troll | Juneau | 9/9/2009 | 37 | NW | ND | ND | 685 |
| 085413 | 041373 | Troll | Yakutat | 9/10/2009 | 37 | NW | ND | ND | 615 |
| 359960 | 041374 | Troll | Sitka | 9/10/2009 | 37 | NW | 154 | ND | 655 |
| 085432 | 041374 | Troll | Yakutat | 9/10/2009 | 37 | NW | 189 | 30 | 640 |
| 085434 | 041374 | Troll | Yakutat | 9/10/2009 | 37 | NW | 189 | 30 | 660 |
| 085436 | 041374 | Troll | Yakutat | 9/10/2009 | 37 | NW | 189 | 30 | 670 |
| 085423 | 041374 | Troll | Yakutat | 9/10/2009 | 37 | NW | 189 | 30 | 690 |
| 085438 | 041374 | Troll | Yakutat | 9/10/2009 | 37 | NW | ND | ND | 435 |
| 998296 | 041373 | Troll | Ketchikan | 9/11/2009 | 37 | NW | 113 | 71 | ND |
| 998310 | 041374 | Troll | Ketchikan | 9/11/2009 | 37 | NW | 113 | 71 | ND |
| 345747 | 041373 | Troll | Hoonah | 9/15/2009 | 38 | NW | 114 | 25 | 540 |
| 345745 | 041373 | Troll | Hoonah | 9/15/2009 | 38 | NW | 114 | 25 | 701 |
| 345756 | 041374 | Troll | Hoonah | 9/15/2009 | 38 | NW | 114 | 25 | 596 |
| 345742 | 041374 | Troll | Hoonah | 9/15/2009 | 38 | NW | 114 | 25 | 600 |
| 345741 | 041374 | Troll | Hoonah | 9/15/2009 | 38 | NW | 114 | 25 | 612 |
| 345753 | 041374 | Troll | Hoonah | 9/15/2009 | 38 | NW | 114 | 25 | 627 |
| 345731 | 041374 | Troll | Hoonah | 9/15/2009 | 38 | NW | 114 | 25 | 684 |
| 345762 | 041373 | Troll | Hoonah | 9/16/2009 | 38 | NW | 114 | 25 | 588 |
| 345801 | 041374 | Troll | Hoonah | 9/17/2009 | 38 | NW | ND | ND | 701 |
| 345778 | 041373 | Troll | Hoonah | 9/18/2009 | 38 | NW | 113 | 91 | 570 |
| 345793 | 041374 | Troll | Hoonah | 9/18/2009 | 38 | NW | 114 | 25 | 612 |
| 364715 | 041374 | Troll | Sitka | 9/18/2009 | 38 | NW | ND | ND | 645 |
| 364712 | 041374 | Troll | Sitka | 9/18/2009 | 38 | NW | ND | ND | 650 |
| 364785 | 041374 | Troll | Sitka | 9/18/2009 | 38 | NW | ND | ND | 655 |
| 345814 | 041374 | Troll | Hoonah | 9/23/2009 | 39 | NW | ND | ND | 566 |
| 345811 | 041374 | Troll | Hoonah | 9/23/2009 | 39 | NW | ND | ND | 641 |
| 365448 | 041374 | Troll | Sitka | 9/24/2009 | 39 | NW | 114 | 23 | 680 |
| 362313 | 041373 | Troll | Craig | 9/2/2009 | 32 | SW | 104 | 40 | 645 |

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| Head number | Tag code | Gear | Port | Recovery date | Statistical week | Quad-rant | District | Sub-district | Length |
|---|---|---|---|---|---|---|---|---|---|
| 343082 | 041374 | Fish wheels | Chilkat River | 8/18/2009 | 34 | NE | 115 | 32 | 455 |
| 343083 | 041374 | Fish wheels | Chilkat River | 8/23/2009 | 35 | NE | 115 | 32 | 460 |
| 343085 | 041373 | Fish wheels | Chilkat River | 9/1/2009 | 36 | NE | 115 | 32 | 430 |
| 343086 | 041374 | Fish wheels | Chilkat River | 9/1/2009 | 36 | NE | 115 | 32 | 385 |
| 343084 | 041374 | Fish wheels | Chilkat River | 9/1/2009 | 36 | NE | 115 | 32 | 545 |
| 343088 | 041373 | Fish wheels | Chilkat River | 9/2/2009 | 36 | NE | 115 | 32 | 625 |
| 343089 | 041374 | Fish wheels | Chilkat River | 9/2/2009 | 36 | NE | 115 | 32 | 540 |
| 343121 | 041374 | Fish wheels | Chilkat River | 9/5/2009 | 36 | NE | 115 | 32 | 575 |
| 343122 | 041373 | Fish wheels | Chilkat River | 9/6/2009 | 37 | NE | 115 | 32 | 580 |
| 343123 | 041374 | Fish wheels | Chilkat River | 9/6/2009 | 37 | NE | 115 | 32 | 625 |
| 343124 | 041373 | Fish wheels | Chilkat River | 9/7/2009 | 37 | NE | 115 | 32 | 680 |
| 343126 | 041373 | Fish wheels | Chilkat River | 9/8/2009 | 37 | NE | 115 | 32 | 510 |
| 343125 | 041373 | Fish wheels | Chilkat River | 9/8/2009 | 37 | NE | 115 | 32 | 625 |
| 343127 | 041374 | Fish wheels | Chilkat River | 9/8/2009 | 37 | NE | 115 | 32 | 745 |
| 343128 | 041374 | Fish wheels | Chilkat River | 9/10/2009 | 37 | NE | 115 | 32 | 620 |
| 343129 | 041373 | Fish wheels | Chilkat River | 9/11/2009 | 37 | NE | 115 | 32 | 540 |
| 343133 | 041374 | Fish wheels | Chilkat River | 9/11/2009 | 37 | NE | 115 | 32 | 540 |
| 343132 | 041374 | Fish wheels | Chilkat River | 9/11/2009 | 37 | NE | 115 | 32 | 690 |
| 343135 | 041373 | Fish wheels | Chilkat River | 9/13/2009 | 38 | NE | 115 | 32 | 325 |
| 343136 | 041373 | Fish wheels | Chilkat River | 9/13/2009 | 38 | NE | 115 | 32 | 550 |
| 343134 | 041374 | Fish wheels | Chilkat River | 9/13/2009 | 38 | NE | 115 | 32 | 725 |
| 343137 | 041373 | Fish wheels | Chilkat River | 9/14/2009 | 38 | NE | 115 | 32 | 550 |
| 343082 | 041374 | Fish wheels | Chilkat River | 8/18/2009 | 34 | NE | 115 | 32 | 455 |
| 343139 | 041373 | Fish wheels | Chilkat River | 9/16/2009 | 38 | NE | 115 | 32 | 600 |
| 343138 | 041374 | Fish wheels | Chilkat River | 9/16/2009 | 38 | NE | 115 | 32 | 700 |
| 343140 | 041374 | Fish wheels | Chilkat River | 9/17/2009 | 38 | NE | 115 | 32 | 480 |
| 343142 | 041374 | Fish wheels | Chilkat River | 9/18/2009 | 38 | NE | 115 | 32 | 445 |
| 343141 | 041374 | Fish wheels | Chilkat River | 9/18/2009 | 38 | NE | 115 | 32 | 455 |
| 343145 | 041373 | Fish wheels | Chilkat River | 9/19/2009 | 38 | NE | 115 | 32 | 580 |
| 343144 | 041373 | Fish wheels | Chilkat River | 9/19/2009 | 38 | NE | 115 | 32 | 585 |
| 343146 | 041373 | Fish wheels | Chilkat River | 9/19/2009 | 38 | NE | 115 | 32 | 625 |
| 343143 | 041373 | Fish wheels | Chilkat River | 9/19/2009 | 38 | NE | 115 | 32 | 630 |
| 343148 | 041373 | Fish wheels | Chilkat River | 9/20/2009 | 39 | NE | 115 | 32 | 485 |
| 343150 | 041373 | Fish wheels | Chilkat River | 9/20/2009 | 39 | NE | 115 | 32 | 500 |
| 343149 | 041373 | Fish wheels | Chilkat River | 9/20/2009 | 39 | NE | 115 | 32 | 570 |
| 343147 | 041374 | Fish wheels | Chilkat River | 9/20/2009 | 39 | NE | 115 | 32 | 690 |
| 343153 | 041373 | Fish wheels | Chilkat River | 9/21/2009 | 39 | NE | 115 | 32 | 570 |
| 343152 | 041374 | Fish wheels | Chilkat River | 9/21/2009 | 39 | NE | 115 | 32 | 580 |
| 343154 | 041374 | Fish wheels | Chilkat River | 9/21/2009 | 39 | NE | 115 | 32 | 610 |
| 343155 | 041374 | Fish wheels | Chilkat River | 9/22/2009 | 39 | NE | 115 | 32 | 590 |
| 343156 | 041374 | Fish wheels | Chilkat River | 9/22/2009 | 39 | NE | 115 | 32 | 630 |
| 343157 | 041374 | Fish wheels | Chilkat River | 9/22/2009 | 39 | NE | 115 | 32 | 670 |

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Appendix A1.–Page 10 of 10.

| Head number | Tag code | Gear | Port | Recovery date | Statistical week | Quad-rant | District | Sub-district | Length |
|---|---|---|---|---|---|---|---|---|---|
| 343160 | 041373 | Fish wheels | Chilkat River | 9/23/2009 | 39 | NE | 115 | 32 | 610 |
| 343158 | 041373 | Fish wheels | Chilkat River | 9/23/2009 | 39 | NE | 115 | 32 | 630 |
| 343161 | 041374 | Fish wheels | Chilkat River | 9/23/2009 | 39 | NE | 115 | 32 | 665 |
| 343159 | 041374 | Fish wheels | Chilkat River | 9/23/2009 | 39 | NE | 115 | 32 | 675 |
| 343163 | 041374 | Fish wheels | Chilkat River | 9/24/2009 | 39 | NE | 115 | 32 | 630 |
| 343162 | 041374 | Fish wheels | Chilkat River | 9/24/2009 | 39 | NE | 115 | 32 | 690 |
| 343164 | 041373 | Fish wheels | Chilkat River | 9/25/2009 | 39 | NE | 115 | 32 | 585 |
| 343165 | 041374 | Fish wheels | Chilkat River | 9/26/2009 | 39 | NE | 115 | 32 | 350 |
| 343167 | 041373 | Fish wheels | Chilkat River | 9/27/2009 | 40 | NE | 115 | 32 | 510 |
| 343166 | 041373 | Fish wheels | Chilkat River | 9/27/2009 | 40 | NE | 115 | 32 | 560 |
| 343169 | 041373 | Fish wheels | Chilkat River | 9/27/2009 | 40 | NE | 115 | 32 | 640 |
| 343168 | 041374 | Fish wheels | Chilkat River | 9/27/2009 | 40 | NE | 115 | 32 | 525 |
| 343172 | 041373 | Fish wheels | Chilkat River | 9/28/2009 | 40 | NE | 115 | 32 | 535 |
| 343170 | 041374 | Fish wheels | Chilkat River | 9/28/2009 | 40 | NE | 115 | 32 | 540 |
| 343171 | 041374 | Fish wheels | Chilkat River | 9/28/2009 | 40 | NE | 115 | 32 | 590 |
| 343173 | 041373 | Fish wheels | Chilkat River | 10/3/2009 | 40 | NE | 115 | 32 | 620 |
| 343174 | 041374 | Fish wheels | Chilkat River | 10/4/2009 | 41 | NE | 115 | 32 | 480 |
| 343175 | 041373 | Fish wheels | Chilkat River | 10/6/2009 | 41 | NE | 115 | 32 | 625 |
| 343176 | 041374 | Fish wheels | Chilkat River | 10/9/2009 | 41 | NE | 115 | 32 | 690 |
| SELECT RECOVERIES | | | | | | | | | |
| 254139 | 041507 | Subsistence | Haines | 9/23/2009 | 39 | NE | 115 | 32 | 585 |

Appendix A2.–Age, sex, and length composition of coho salmon sampled at the Chilkat River fish wheels, and estimated escapement in the first of 2 time strata, July 14–September 19, 2009.

| | Brood year and age class | | | | | |
|---|---|---|---|---|---|---|
| | 2007 | 2006 | 2006 | 2005 | | |
| | 1.0 | 2.0 | 1.1 | 2.1 | Total aged | Total sampled[a] |
| **Females** | | | | | | |
| Sample size | | | 125 | 18 | 143 | 338 |
| Percent | | | 28.9 | 4.2 | | 32.9 |
| SE | | | 2.2 | 1.0 | | 1.5 |
| Number | | | 7,178 | 1,034 | | 8,211 |
| SE | | | 1,705 | 330 | | 1,820 |
| Mean length | | | 614 | 631 | | |
| SD | | | 54 | 70 | | |
| **Males** | | | | | | |
| Sample size | 1 | 9 | 255 | 24 | 289 | 690 |
| Percent | 0.2 | 2.1 | 59.0 | 5.6 | | 67.1 |
| SE | | 0.7 | 2.4 | 1.1 | | 1.5 |
| Number | 57 | 517 | 14,643 | 1,378 | | 16,595 |
| SE | | 203 | 3,357 | 410 | | 3,664 |
| Mean length | 275 | 304 | 537 | 573 | | |
| SD | 0 | 16 | 113 | 85 | | |
| **All fish[b]** | | | | | | |
| Sample size | 1 | 9 | 380 | 42 | 432 | 1,031 |
| Percent | 0.2 | 2.1 | 88.0 | 9.7 | | 50.8 |
| SE | | 0.7 | 1.6 | 1.4 | | 1.1 |
| Number | 57 | 517 | 21,820 | 2,412 | | 24,806 |
| SE | | 203 | 3,765 | 526 | | 5,604 |
| Mean length | 275 | 304 | 562 | 598 | | |
| SD | | 16 | 104 | 83 | | |

[a] Includes fish not assigned an age.
[b] Includes fish with no sex information.

Appendix A3.–Age, sex, and length composition of coho salmon sampled at the Chilkat River fish wheels and estimated escapement in the second of 2 time strata, September 20–October 9, 2009.

| | Brood year and age class | | | | | |
|---|---|---|---|---|---|---|
| | 2007 | 2006 | 2006 | 2005 | | |
| | 1.0 | 2.0 | 1.1 | 2.1 | Total aged | Total sampled[a] |
| **Females** | | | | | | |
| Sample size | | | 141 | 43 | 184 | 452 |
| Percent | | | 36.5 | 11.1 | | 45.5 |
| SE | | | 2.5 | 1.6 | | 1.6 |
| Number | | | 8,789 | 2,680 | | 11,469 |
| SE | | | 2,067 | 713 | | 2,499 |
| Mean length | | | 595 | 648 | | |
| SD | | | 57 | 38 | | |
| **Males** | | | | | | |
| Sample size | | 6 | 161 | 35 | 202 | 542 |
| Percent | | 1.6 | 41.7 | 9.1 | | 54.5 |
| SE | | 0.6 | 2.5 | 1.5 | | 1.6 |
| Number | | 374 | 10,036 | 2,182 | | 12,591 |
| SE | | 170 | 2,342 | 600 | | 2,987 |
| Mean length | | 314 | 591 | 621 | | |
| SD | | 8 | 82 | 81 | | |
| **All fish[b]** | | | | | | |
| Sample size | | 6 | 302 | 78 | 386 | 1,000 |
| Percent | | 1.6 | 78.2 | 20.2 | | 49.2 |
| SE | | 0.6 | 2.1 | 2.0 | | 1.1 |
| Number | | 374 | 18,825 | 4,862 | | 24,061 |
| SE | | 170 | 3,124 | 932 | | 5,435 |
| Mean length | | 314 | 593 | 636 | | |
| SD | | 8 | 72 | 62 | | |

[a] Includes fish not assigned an age.
[b] Includes fish with no sex information

# APPENDIX B

Appendix B1.–An alternate smolt abundance estimator using two tagging groups and differential recovery rates.

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Coded wire tagging coho salmon smolt in different size groups allows for testing of mark-recapture assumption [a], i.e., that every fish has an equal probability of being marked during event 1, that every fish has an equal probability of being captured in event 2, or that marked fish mix completely with unmarked fish. In the event that chi-square tests indicate unequal probabilities of tagging in event 1 or capture in event 2, an alternate Peterson mark-recapture model will be used for a 2-group population.

A population divided into 2 groups labeled (1) and (2), Peterson's mark-recapture model can be expanded into:

$$N_1 + N_2 = (N_1\alpha_1 + N_2\alpha_2)\frac{N_1\alpha_1 S_1 B_1 + N_2\alpha_2 S_2 B_2 + N_1(1-\alpha_1)S_1 B_1 + N_2(1-\alpha_2)S_2 B_2}{N_1\alpha_1 S_1 B_1 + N_2\alpha_2 S_2 B_2} \quad \text{(B.1)}$$

In the above equation, $N$ is abundance, $\alpha_i$ is the capture probability in event 1 for each group, $S_i$ the survival rate for each group, and $\beta_i$ the capture probability for each group.

If one or both capture probability parameters, $\alpha_i$ or $\beta_i$, are equal, then the above equation reduces to a more simplified version. Consider the case when $\beta_1 = \beta_2$, the abundance estimator reduces to:

$$N_1 + N_2 = (N_1\alpha_1 + N_2\alpha_2)\frac{N_1\alpha_1 S_1 + N_2\alpha_2 S_2 + N_1(1-\alpha_1)S_1 + N_2(1-\alpha_2)S_2}{N_1\alpha_1 S_1 + N_2\alpha_2 S_2} \quad \text{(B.2)}$$

If the relationship between $\alpha_i$ parameters is expressed as A= $\alpha_2 / \alpha_1$ and the relationship between $S_i$ parameters is expressed as B = $S_2 / S_1$, equation (B.2) reduces further to:

$$N_1 + N_2 = \frac{(N_1 + AN_2)(N_1 + BN_2)}{N_1 + ABN_2} \quad \text{(B.3)}$$

It is important to note that equation (B.3) is only true if $A$ = 1 (i.e. $\alpha_2 = \alpha_1$) OR if $B$ = 1 ($S_2 = S_1$). If both $A$ and $B$ are not equal to 1, the above relationship does not hold and an unbiased estimator of abundance cannot be produced. If it is determined that there are both unequal marking probabilities (event 1) and unequal capture or survival probabilities (event 2), Peterson's model can be adjusted to produced an unbiased estimate of smolt abundance. Consider Chapman's modification of the standard Peterson model with two tagging groups, labeled group 1 and group 2:

$$\hat{N} = \frac{(N1_1 + N1_2 + 1)(N2 + 1)}{(M2_1 + M2_2 + 1)} \quad \text{(B.4)}$$

where $N1_1$ and $N1_2$ are the number marked in groups 1 and 2, $N2$ is the number inspected for marks in the second event, and $M2_1$ and $M2_2$ are the amount of marks recovered from groups 1 and 2. Consider the case where $A > 1$ and $S > 1$, that is, group 2 had both a higher marking probability and capture probability. This would create a negative bias in the estimator and $N > \hat{N}$. Adjusting Chapman's modification for this tagging bias results in a new, unbiased estimator:

$$\hat{N}^* = \frac{\left(\hat{A}N1_1 + N1_2 + 1\right)\left(N2 + 1\right)}{\hat{A}M2_1 + M2_2 + 1} - 1 \qquad \text{(B.5)}$$

Using the scaler $\hat{A}$, i.e. the ratio of marking rates of the 2 groups, essentially forces the 2 groups to have the same marking probability, and therefore the expected value of equation (B.5) equals $N$ as a result.

Retention rates for coded wire tagged fish are rarely 100%; adipose-clipped fish sometime do not contain valid CWTs as tags are shed during freshwater or marine rearing. Also occasionally heads are lost from adipose-clipped fish before they can become decoded. Because of this, a new parameter $\hat{\pi}$ can be used to adjust for adipose-clipped fish with no tag information ($M2_U$), which is the observed ratio of tags recovered from group 1 divided by group 2. Basically the observed recovery rate is extrapolated for fish marked in the first event (as indicated by an adipose fin clip) that contain no tag information:

$$\hat{N}^* = \frac{\left(\hat{A}N1_1 + N1_2 + 1\right)\left(N2 + 1\right)}{\hat{A}\left(M2_1 + \left(\hat{\pi}\right)M2_U\right) + M2_2 + \left(1 - \hat{\pi}\right)M2_U + 1} - 1 \qquad \text{(B.6)}$$

In the event that all observed adipose-clipped fish contain valid coded wire tags, the term $M2_U$ is zero and equation (B.6) is identical to equation (B.5).

Variance and relative bias in the modified estimator can be estimated through bootstrapping techniques outlined in Efron and Tibshirani (1993).

# APPENDIX C

Appendix C1.–Computer files used in the analysis of data for this report.

| File name | Description |
|---|---|
| 08ChilkatCohoSmolt.xls | Excel workbook containing 2008 Chilkat River coho salmon smolt trapping, CWT release, smolt emigration estimator, and age-weight-length data. |
| 09ChilkatCohoFWanalysis.xls | Excel workbook containing 2009 Chilkat River fish wheel coho salmon catch, marking, and age-length sample data. |
| 09ChilkatCohoCWTrecoveries.xls | Excel workbook containing CWT recovery data and harvest estimates of Chilkat River coho salmon tagged as smolt during 2008. |
| DiscussionFiguresTables0809ChilkatCoho | Excel workbook containing figures and tables used in the discussion section of the 2008–2009 Chilkat River coho salmon FDS report |